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Residential Water Conservation in Austin, Texas.

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by

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Residential Water Conservation in Austin, Texas.

by

Luke A Sires, MSSD

The University of Texas at Austin, 2009

Supervisor: Steven A Moore

This study explores the social, technological economic, and environmental development of single-family residential water conservation programs at the Austin Water Utility and asks: *What makes a conservation program successful?* I hypothesize that water conservation programs will be successful if both institutional-producer goals and citizen-consumer goals are satisfied. While the findings suggest that this may be partially true, it also has become clear that my original actor-network model was too simple to predict the various types of influences on program success. Not only did I find other significant 'actors' involved in water conservation, I also found that utility and participant groups themselves represent a wide variety of interests.

This study seeks to answer the research question by creating a series of narratives that critically explore water infrastructure and water conservation programs in Austin, Texas. Through a methodological lens referred to as 'critical constructivism,' I use mixed methods to analyze and interpret historic documents, interviews, and quantitative data as primary sources. Literature from Science and Technology Studies (STS) are used as secondary sources.

This study will add to a body of knowledge that describes *how* and *why* we manage our environmental resources. The subject of conservation is especially relevant as urban growth continues with fewer affordable opportunities to increase regional water supplies. As we enter an era of expected water conflict, knowing how to conserve water effectively will help provide more opportunities for sharing a common resource amongst communities, industry, agriculture, and the environment.

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List of Acronyms and Abbreviations:

af	acre-feet
ANC	Austin Neighborhoods Council
ANT	Actor-Network Theory
AWU	Austin Water Utility
AWWA	American Water Works Association
gpcd	gallons per capita (per) day
gpd	gallons per day
gpf	gallons per flush
LCRA	Lower Colorado River Authority
mgd	million gallons (per) day
SAWS	San Antonio Water System
SAS	Statistical Analysis System
SOS	Save our Springs Alliance
STS	Science and Technology Studies
TCEQ	Texas Commission on Environmental Quality
TWC	Texas Water Commission
TWDB	Texas Water Development Board
WWWC	Water and Wastewater Commission

Chapter 1: Introduction

Background:

My interest in water conservation programs developed from several long-held interests as well as more recent research and writings through my master degree studies. Previous interests included participatory planning methods, sustainable development (at an urban scale), and resource management. At UT my interest in participatory development shifted towards citizen-expert relations and policy and code-making. Researching water conservation, as a form of resource management, complimented these other interests, since it is a major concern for citizens, planners, policy-makers, and designers. So, while this thesis is about water and water conservation programs, it is also very much about my other two fields of interest: programs or 'codes', and citizen-expert relationships.

Water conservation programs are policies created by the Austin Water Utility (AWU) to offer citizen-consumers new opportunities to reduce water consumption, typically through efficient technologies and water-use education. I found water conservation programs interesting because they show deliberate choices by program developers to enable, and in some senses disable, opportunities for citizen-consumers. I was also intrigued that the Austin Water Conservation Division evaluated some programs in ways that I found, at first, to be counter-intuitive. This was most notable in their decision to maintain their rain barrel sales program while terminating the landscape rebate program – even though early reasoning suggested that they performed similarly. My interest in program structure and inability to understand why certain programs were pursued, while others were not, led to the creation of this study.

The City of Austin has numerous types of water conservation programs beyond the single-family residential programs examined in this thesis. Their commercial, multi-family, and reclaimed water conservation programs, as well as modification of building codes, all contribute significantly to the City's ability to lower water consumption. I found the single-family programs to be particularly interesting because of the unique ways they engage and empower the public to contribute to the management of their water resource system.

The public citizen and water consumer, referred to in this thesis as the citizen-consumer, has a unique position of both acting as a consumer of resources and services, and a limited role as a decision maker that influences the planning and development process for the local water resource system.[1] Citizen-consumers who have completed at least one water conservation program are referred to as participants. These roles of the citizen-consumer may conflict

[1] The term 'citizen-consumer' is used to express this dual role of the water user. It is important to acknowledge that all water users are not necessarily citizens, and that non-citizens may have a very different affiliation to city run programs.

at times, especially when there is a desire or need to both consume and steward a resource.

Austin Water Utility, like other public utilities, also serves a dual function as an institution and producer. As an extension of the public municipal government, the utility has an institutional role directly tied to the city and its citizens. The utility also is a producer of infrastructure, services, knowledge, and products. The term institution-producer will be used to describe these unique roles. These roles, like those of the citizen-consumer, have conflicting interests to both steward and produce.

Research Question:

This study explores the social, technological, economic, and environmental development of single-family residential water conservation programs at the Austin Water Utility and asks the research question: *What makes a conservation program successful?* I hypothesize that water conservation programs will be successful if both institutional-producer goals and citizen-consumer goals are satisfied. For the purpose of testing this hypothesis, successful programs will be defined as programs that reduce participants' water use.

This study seeks to answer the research question by creating a series of narratives that critically explore water infrastructure and water conservation programs in Austin, Texas. Through a methodological lens referred to as 'critical constructivism,' I use mixed methods to analyze and interpret historic documents, interviews, and quantitative data. Primary sources are used throughout the study, and new data was created for the interview and internet study sections. Secondary sources are used in two ways. First, relevant literature from the field of Science and Technology Studies (STS) provide a theoretical framework for interpreting and analyzing findings throughout the study. Second, they provide context and support findings for the interpretive-historic methods used to create a history of infrastructure and conservation in Austin.

This study will add to a body of knowledge that describes *how* and *why* we manage our environmental resources. The subject of conservation is especially relevant as urban growth continues with fewer affordable opportunities to increase regional water supplies. As we enter an era of expected water conflict, knowing how to conserve water effectively will help provide more opportunities for sharing a common resource amongst communities, industry, agriculture, and the environment.

While the findings suggest that the hypothesis is partially valid, they also show that my original actor-network model was too simple to predict the complex system dynamics that influence how programs achieve success. Not only did I find other significant actors involved in water conservation, I also found that utility and participant groups themselves represent a broad range of competing interests.

Chapter Descriptions:

In Chapter 2, I will explain the key epistemological framework used to design the study as well as the specific tactics used to produce and interpret the results. This will be followed, in Chapter 3, by a review of basic literature that contributes a theoretical context through which the results are interpreted.

In Chapter 4, I will depart from this theoretical framework and discuss relevant regulatory, climatic, geographic, and demographic background information for Austin. Chapter 5 provides an in-depth history of how water infrastructure and water conservation developed in Austin. Chapters 6-8 will examine interview, internet survey, and quantitative findings in detail.

In Chapter 9, I will review the key findings from chapters 5-8. After this summary I will synthesize the theory and literature by constructing findings relevant to my original hypothesis. Finally, I will make recommendations for future conservation policy and suggest areas of interest for further research.

Chapter 2: Methodology and Methods

As a student of Science and Technology Studies (STS) I interpret science and technology within a social context. This process requires a diverse set of theories that provide a framework that enable interpretation of how citizen-consumers, institution-producers, and other stakeholders interact to reach their respective goals. The following sections will describe the theoretical framework and the various qualitative and quantitative strategies used to answer the research question.[2]

Methodology:

Methodology refers to the epistemological framework through which the strategic methods are designed and interpreted. I will use two key research qualities to describe how my methodology produces both valid and valuable knowledge. These qualities are *inquiry aim* and *criteria for quality*.

[2] Some of the explanations of methods used may seem obvious, or seem to be part of all forms of research, and therefore may seem unnecessary to explain. I have explained these seemingly obvious methods for two reasons. First of all, while explaining the methods I can define terms that I will use throughout the study. This will make the language less opaque to readers. Second, by leaving aspects of the study unexplained, critical aspects of the study will remain in a 'black-box' and be unavailable to the reader for scrutiny. Explaining all aspects of the study allows the reader to better evaluate the study's validity.

The *inquiry aim* describes the key objective of one's research and analysis. *The epistemological purpose of this study is to critically evaluate and construct an understanding of how social, technological and environmental influences shape our relationship to water, infrastructure, and the environment.*

Criteria for quality refers to the researcher's sense of academic rigor or the approach to creating valuable and valid data and analysis. I will create valuable and valid data and analysis by using historically situated data, interpreted and analyzed to construct an understanding of past events. For this study I have chosen to use both qualitative methods, to learn about the infrastructure, programs, institutions, and citizens themselves, and a quantitative methods to better understand water-use as well as determine if the programs are successful. While these two methods often use different types of data, I use similar criteria to judge the value and validity for them both. Data for each was collected from reliable sources and was examined critically with the assistance from a variety of knowledgeable stakeholders. Since the quantitative analysis in this study provides useful clues about the past, it will actually be integrated as part of the broader historical perspective developed using qualitative methods.

This epistemological framing I have adopted for this study is often academically referred to as 'critical-constructivism'. The critical-constructivist uses constructivist tools to create knowledge driven by an emancipatory goal to “erode ignorance” and reveal hidden assumptions.[3] Following this perspective, results from the qualitative methods and quantitative model are not interpreted as predictions about the future; rather, they represent lessons about the past. Quantitative models, as well as historical narratives, are only useful to predict the future to the degree that the future is like the past. Such an assumption about the future is tenuous. The world is ultimately very messy and, as quantitative modeler Dr. Reuben McDaniel likes to explain, complex systems such as cities and urban growth, are fundamentally unpredictable.[4] Therefore the quantitative study can at best help provide insights into what happened in the past. By integrating this with other narratives I hope to be able to reach conclusions about how we have arrived where we are. A more critical and complete understanding of the past will allow informed citizens, planners, and designers to better decide how to proceed from the present.

The results from the multiple methods used will be ‘triangulated’ – a method of cross-referencing to show if and how the various methods support similar conclusions. When this cross-referencing supports contradictory conclusions, triangulation provides an opportunity to explain discrepancies or the need for further inquiry.

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[3] Lincoln, Egon and Guba, *Naturalistic Inquiry* (1985). Taylor and Dawson, *Critical Reflections on a Problematic Student-Supervisor Relationship* (1988), 105.

[4] City Forum Panel, *Moving Forward, Looking Back: Institutionalized Racism and the Complexity of Urban Space.* The University of Texas at Austin, (February 2nd, 2009).

Methods:

I have chosen certain strategic methods and tactics because I believe they can successfully answer the question at hand. Key influences to my pragmatic decision-making were my identity as a student, and accessibility of data and resources.

As a student I have a dedicated, but limited, amount of both time and expertise. I have chosen some methods and strategies for this thesis to fulfill my need for learning, just as much as to fulfill the need to create new knowledge. My position as a student, in conjunction with the critical constructivist framing of the study, led to the pursuit of an 'emerging hypothesis.'

Following an emerging hypothesis, in contrast to a static hypothesis, allows the focus and methods of the study to evolve, as the researcher's understanding of the data coalesces around new insights. For instance, while conducting qualitative interviews, I became aware that using rainfall data as a covariate in my quantitative model would create more nuanced and credible results. This adaptiveness in research design extends throughout the thesis process.

Accessibility of data and resources has fundamental implications for research design and method selection. Studying social, environmental, and technological aspects of one's current place of residence, which Austin is for me, can lead to a much more manageable project. The accessibility of data also made it possible to include quantitative methods. Without the Austin Water Utility's decision to give me such detailed spatially referenced water-use and participation data, I would likely not have pursued a quantitative study at all. Similarly, due to the relatively short research period, conducting interviews with a hundred water customers and conservation program participants would have been prohibitively time consuming. For this reason I decided to pursue a internet based survey instead.

The individual strategies used by the mixed method approach are: *interpretive-historical*, *interviews*, *internet survey*, and *quantitative analysis*. These strategies will be integrated and triangulated using *narrative construction* and *logical argumentation*. The following sections will describe how each of these strategies were used to collect and interpret data.

Interpretive-historical:

The goal of interpretive-historical tactics is to understand and describe a history through the construction of narratives.[5] The constructivist approach to narrative construction generally relies on the development of multiple stories that together form a coherent explanatory system.

[5] Groat and Wang, *Architectural Research Methods* (2002), 45-79, 135-167.

In this case the search for relevant historic documents began by identifying and investigating a succession of events that helped me try to understand the general context. At first, each new piece of data led to development of new questions, which precipitated the need for new data. New data were encountered by examining references from current resources, as well as making inquiries through academic and professional networks. The first data that helped create a preliminary narrative originated in lectures, course readings, and relevant internet repositories. Questions arising from this first understanding led me to increasingly specific sources within various archives, and texts written by others exploring similar topics. Resources at the Center for American History, Austin History Center, Perry-Castañeda Library, and the online Austin City Clerk Archives were used extensively.

The collected data were stored both as physical copies and digital files, and were interpreted throughout the study by creating storylines and timelines of relevant content. These narratives were compared with other data received during interviews to test for completeness. When interview data suggested that the interpretive-historical process was incomplete, further research was conducted to attempt to corroborate the new information. The wealth of information available and the relative breadth of Austin's history provides challenges to create a succinct, yet complete, understanding of infrastructure and water conservation. Because of this challenge, many seemingly important aspects of this history could not be included due to the scope of this thesis project. With this in mind several factors were evaluated to determine the completeness of the interpretive-historical research. First, key theories were used to determine important historic periods of interest. These periods are the establishment of a centralized water system in Austin and the establishment of water conservation programs in Austin. Second, historic events were examined based on when data and insights from the various strategies suggested that they were important.

Interviews:

Interviews, or 'recollective interpretation,' provide a key way to learn about topics quickly and also access information that may lack documentation. The interactive nature and wealth of data collected through interviews provides nuance to existing story lines and occasionally provides insight for completely new narratives.

Interviews are subject to human experimentation policy at the University of Texas and require particular care to protect the respondents' identity. For reasons of confidentiality and privacy, all respondent names used in this thesis are pseudonyms. Similarly, their professional history and current position must also remain confidential. All professional references will be limited to a general description of the type of information they are familiar with. While it is difficult to assure trustworthiness of information with this degree of anonymity, I can state that all respondents were professionals related to the field. Furthermore, respondents readily recommended other individuals to interview that could verify and add to the body of knowledge. The process of receiving stories from respondents began with a small list of individuals whom I ascertained were familiar with the relevant topics, which was then extended into a longer list through references. Ultimately I conducted 10 formal interviews.

All interviews were recorded and transcribed by the author. After transcription, I began a process of manual content analysis. This involved parsing the received stories into discrete pieces of knowledge recorded individually on 3 x 5 note cards. After transcribing all relevant sections of the interviews I mixed the deck of cards and began a process of organizing them into categories based on narratives and theoretical frameworks. Through this process I was able to integrate the various received stories into a cohesive narrative and explore the applicability of various theories. The results from this process were then integrated within the narratives in the history presented within Chapter 5, as well as Chapters 6 and 9.

Internet Survey:

An internet survey was conducted in order to understand water consumers and water conservation participants better. This internet-based format allowed for a quick, broad survey of the public's attitude towards key water conservation concerns. This internet survey was designed as a supplement to both the interview data, and the 2004 Enviromedia study, the "Texas Water Conservation Survey."[6]

An invitation for the survey was distributed to two local list serves via an introductory email. The two list serves used were the Austin Eco-Network, which represents a large constituency of environmentally predisposed residents and professionals within the environmental field, and the Austin Neighborhoods Council forum "ANC Talk", which generally reaches a group of citizens interested in community and development issues. The email and introductory website, which was maintained by the author, described the purpose of the survey. Participants were informed in the email and on the website that their privacy and confidentiality would be maintained. The introductory website contained a link leading to a third party site that facilitates Internet surveys and contained a survey with 16 questions written and formatted by the author. All aspects of the survey protocol were provided in both English and Spanish. Additional details about the survey are located in the appendix.

The data produced by this survey is interpreted by cross-referencing participant responses to various question and comparing the results. This

[6] Enviromedia (Baselice & Associates Inc.), "Texas Water Conservation Survey" (2004). Enviromedia conducted the Texas Water Conservation Survey", which surveyed 1,200 respondents

process was facilitated by an online tool within the survey website that compares responses from various questions. This enabled me to gain insight into participant preferences, and attitudes towards conservation.[7] The questions I was seeking to answer through this process include: 1) Why do respondents want to conserve; 2) How does respondent participation in conservation programs differ between respondents; 3) What are respondents attitudes towards water conservation programs and technologies; and 4) How does the Internet survey data corroborate conclusions from the other strategies or suggest alternative conclusions?

Quantitative Analysis:

In order to gain insight into the success of water conservation programs, a quantitative study analyzed the water consumption of some of Austin Water's single-family residential customers. The data includes water consumption history from thousands of participants and more than a hundred-thousand non-participants between 1995 and 2006. A model was developed to examine consumption trends among water conservation program participants and other water users. The model also analyzed the interaction between water-use and

[7] See the Internet survey question and response section of the appendix for tables used in this process.

four covariates. Table 1, on page 19, lists and provides information about the data.

The model was developed and analyzed with assistance from the UT Statistics + Scientific Computation Department's consulting services during the Spring and Summer Semesters, 2009. The model runs on Statistical Analysis System (SAS) software and was developed and processed on the UT Window Terminal Services Network. Data files created for the model were processed by the author using ESRI's ArcMap 9.2 geographic information system (GIS) software from data sources listed in Table 1.

The model evaluates the change in water use for participants in various water conservation programs over a five-year period, from two years before participation, to two years after participation, plus the year of participation. The model evaluates six water conservation programs: free toilets, toilet rebates, washer rebates, irrigation audits, rain barrel sales and landscape rebates. All variables were mean-centered, a process of making the data relative to its average, to ensure that results for all programs could be accurately compared with each other.

These programs were chosen because they represented a broad sample of the types of residential water conservation programs conducted by Austin Water. While I received data for three additional programs – irrigation rebates, rainwater harvesting, and rain barrel rebates – the programs were dropped from the study because they contained insufficient data resulting in insignificant preliminary results. Furthermore, the results from the irrigation audit and rain barrel sales programs already provided insight into two of these programs. While the two toilet programs are similar, I decided to analyze both because the different preliminary findings were both significant and noteworthy.

The raw data underwent an extensive data selection process using GIS to ensure that only data relevant to the study was used in the model. The extent of this process is noted in the two columns listing the numbers of data points in Table 1. Water use data was selected for single-family residential households for which data was present for all covariates. All participant data used in the model contained a start date and was cross-referenced with water use data. Other measures were used within SAS to exclude data that might be erroneous, unrepresentative of most single-family households, or that exhibited signs that the household was uninhabited for a substantial period of time. This was accomplished by excluding water use data from meters that measured less than 12,000 gallons of use in a year, as well as data linked to parcels greater than 1 acre or less than 5000 $ft.^2$, or data linked to building footprints greater than 5,000 $ft.^2$ or less than 300 $ft.^2$ After running the model with monthly rainfall data for the entire year and just for months May-September it was determined that, while there was only a marginal difference, summer rainfall best predicted water use. This was likely the case for two reasons: First, rainfall is not evenly distributed throughout the year in Austin, and any one year may receive a large percentage of its rainfall in one or two months. Secondly, the hot and frequently dry summers in Austin promote the largest amount of outdoor watering for most customers. Quantitative analysis suggested that summer rainfall predicted yearly water consumption for single family Austin residents better than the total yearly rainfall. For this reason, only summer rainfall data was used for the rainfall covariate.

Table 1: Metadata for Quantitative Analysis.

Data Description	Date	Number of data points	Used data points	Data Source	Key unit of measurement(s)
Water Consumption	1995-2006	1.5 million	41,698	Austin Water Utility	Gallons measured by a meter
Program Participation:					
Free Toilet Program	1994-2005	24,744	20,052	Austin Water Utility	Start date, number of times participated
Toilet Rebate Program	1992-2005	8,675	2,496	Austin Water Utility	Start date, number of times participated
Irrigation Audit Program	1998-2005	1,573	1,293	Austin Water Utility	Start date, number of times participated
Washer Rebate Program	1998-2005	10,795	8,728	Austin Water Utility	Start date, number of times participated
Rain Barrel Sales Program	1999-2005	2,147	1,986	Austin Water Utility	Start date, number of times participated
Landscape Rebate Program	1998-2005	444	210	Austin Water Utility	Start date, number of times participated
Covariates:					
Rainfall	1995-2006	144	12	National Oceanographic and Atmospheric Administration	Average rainfall for May-September in inches
Average Household Size	2000	11,292	5,330	US Census	Number of inhabitants
Building Footprint Size	2003	371,577	139,042	City of Austin	Area of house
Property ID and Lot Size	2008	300,000+	139,042	Travis County Appraisal District	Area of lot

Narrative Construction:

Narrative construction describes the synthesis of various historical sources into a meaningful understanding of past events – a story. The tactics or specific manner used to ascertain the information used are numerous. I used narrative construction as a mode of data collection and interpretation to develop findings for historical documents and interviews. The two predominant strategies that I used are *determinative evidence*, and *recollective* – referred to here as *interpretive-historical*, and *interviews,* respectively.[8]

Logical Argumentation:

Logical argumentation is a fundamental way of interpreting data within a rational framework. Using logical arguments, individual pieces of data were organized to build new ideas.[9] Said another way, logical argumentation is about making sense out of data using a rational system. I use different rational systems for the various methods depending on what needs to be described. For the interpretive-historical, interview, and internet survey, several rational systems were borrowed from the theories discussed within the literature review in order to

[8] Groat and Wang, 2002. 154,159.

[9] Groat and Wang, 2002. 93, 301-335.

draw larger conclusions. The quantitative study used a mathematical system of logic to determine and analyze numeric information describing measured social, environmental and technological variables. However, as mentioned earlier, the results from the quantitative study were also used to add to the narrative construction, during which period other theoretical frameworks will be employed to aid in their interpretation.

While logical arguments occur throughout the thesis in some form, narrative constructions primarily take place in chapters 5, 6, and 7. Both methods come together in chapter 9 for the integrated analysis.

Conclusion:

Interpretive-historical, interview, internet survey, and quantitative methods are used to find and interpret data to test the hypothesis. The results from these methods are triangulated to cross reference the various conclusions. This process tests the strength of the conclusions by examining how they are or are not supported by evidence from the multiple strategies. The reliability of the methods are dependent on their quality and completeness. This process of triangulation helps account for potential weaknesses in quality and completeness by relying on verification through multiple methods. Furthermore, the various methods produce significantly different types of results. The diversity of results is important not only to hound out weak information and conclusions, but also to reveal why certain results were produced by the various methods. The process of triangulation lends both validity and significance to individual conclusions.

Chapter 3: Literature Review

The Science Technology Studies (STS) literature helps provide theoretical background to refute oversimplified assumptions and support realistic modes of analysis regarding how we build, and how our building affects us. I will approach this literature by using three deterministic paradigms, social, market, and technological, to organize and describe the variety of theories available and relevant to this study. Organizing the literature in this way will enable a comparison between similar types of theories relevant to this study. These categories were chosen for two reasons: First, I believe the categories are familiar for readers and should make the subject matter clear and accessible. Second, by organizing the literature in this way it will become clear how traditional disciplinary categories fail to create a comprehensive understanding of the real world.

Before discussing the deterministic paradigms I will describe one particular theory that is key to my hypothesis and interpretation in this thesis – Actor-Network Theory (ANT). Throughout the description and discussion of these paradigms, I will continue to use ANT to frame each paradigm. I will conclude by discussing how the theories used in this thesis create relationships between multiple deterministic paradigms.

Actor-network Theory:

The theory most relevant to this hypothesis is Actor-Network Theory (ANT), which is used to describe how events or policies are determined by networks of people and things. ANT was developed by various scholars contributing to the field of Science and Technology Studies (STS), but most notably French Academics Michael Callon and Bruno Latour. Actor Network Theory holds that social developments are created by a network of actors, most notably people and institutions, and artifacts such as technologies, policies, and resources.[10]

My hypothesis – that water conservation programs will be successful if institution-producer goals and citizen-consumer goals are both satisfied – describes an actor-network. The citizen-consumer and institution-producer actors create a social network that is facilitated through the water conservation program's artifacts. This network also implicitly includes water meters which are required to measure the successful reduction of water use as outlined by this study. This hypothesis presupposes that the citizen-consumer and institution-producer have some common, but also different and competing interests. The problem presented by my hypothesis, interpreted using Actor-Network Theory, is how to have the common interests of institutions, citizens, and other actors dominate the network.

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[10] Latour, *Politics of Nature* (2004). Callon, *The Social Construction of Technological Systems* (1987).

According to Latour, actors and artifacts are differentiated by the presence of consciousness and freedom. While actors are "endowed with consciousness, speech, will, and intention," artifacts "obey only chains of causality."[11] Policy such as water conservation programs are not capable of self-determined actions like citizen-consumers and institution-producers. An actor-network for Austin's water system and conservation programs will be shown in the following chapters.

Actor-network theory is often used to create a better understanding of the procedures through which actors and artifacts influence their network to produce specific changes. In the *Domestication of the Scallops and the fishermen of St. Brieuc Bay*, Michael Callon outlines a process of 'translation' where actor's and artifacts define problems, solutions, and roles in order to fulfill maintenance or transformation of the network.[12] Through his study Callon shows how actors modify their network by creating new roles for other actors and artifacts. This analysis provides insights into how value systems frame problems that promote desired future conditions, and how the public and infrastructure is represented by other actors. Analysis throughout this thesis will use Callon's concepts of translation to create a more in-depth understanding of building and adapting Austin's water infrastructure and water conservation programs.

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[11] Latour, *Politics of Nature* (2004), 73.

[12] Callon, *Some Elements of a Sociology of Translation* (1986).

Deterministic Paradigms:

There are many deterministic paradigms which inaccurately claim that certain conditions are caused by a specific factor, such as technology or politics. The broad categories I will use are social determinism, market determinism, and technological determinism. In this section I will briefly describe how STS and related literatures describe common fallacies and relevant theories for several important determining factors.

Social Determinism:

Social determinism proposes that key actors in society can predict or control the outcome of some or all situations. Historian Walter Prescott Webb dismissed purely socially determined problem-solving methods in response to water supply needs during the 1950s when he wrote that "any plan that promises quick relief through human agency is a fraud."[13] While I don't necessarily agree with his conclusion, there is truth within the underlying concept that, even if we had total administrative agency, or a perfect educational medium for spreading awareness about the need for water conservation, the act of conservation is limited by key non-social factors such as the availability of water. Social methods

[13] Webb, *More Water for Texas: The Problem and the Plan* (1954).

for influencing water use, such as creating mandatory water policy, are dependent on a society that can follow rules well enough to achieve success. While these vague claims against social determination are valid, more refined social theories are applicable to such problems. Actor-Network Theory, described previously in this chapter, and Regime Theory are two useful approaches to understanding social influences.

Regime Theory is a sub-category of Actor Network Theory within socially deterministic theories that provides a framework for analyzing what is often referred to as local politics. Regime Theory holds that regional policy is influenced by a dominating coalition, or regime, of local interests – especially those whose financial-capital or business relations are tied to place. Typically real estate associations are portrayed as an exemplar member within such a coalition since they are in all respects land-based. However, other less land based trades can become linked to a place because of an aggregate professional presence, such as the movie industry in Hollywood, automobiles in Detroit, and digital technology in Silicon Valley.

Urban regimes as an actor-network consist of groups of actors described as "a governing alliance between land-based business interests and local public officials." This alliance typically pursues "an urban agenda heavily oriented toward achieving economic growth in the city via so-called corporatecenter/mainstream development strategies."[14] Political scientist David Imbroscio acknowledges that in order to institute policies that are not supported by the existing dominant regime, a coalition of smaller groups must unite to overcome the dominant regimes' control of affairs.[15]

Imbroscio's writings are helpful because they highlight key actors and artifacts as well as suggest ways that those interested in producing new results can align themselves within this network to create more political equality. Social determinism as understood through Actor-Network Theory and Urban Regime Theory does not predict outcomes merely due to social forces. Rather, these theories suggest that events can be explained by diverse relationships between actors and artifacts, including land and commodities tied to land.

One way that cities and citizens try to modify the practices of the urban regime as well as the actor-network is through the development of codes. Andrew Feenberg theorizes that codes, whether they be urban zoning ordinances, civic laws or building regulations, represent how societies come to closure around how to value and practice social norms.[16] Water conservation programs represent a type of voluntary, or incentive-based code. By developing voluntary codes, such as limitations on watering and replacing toilets, city leaders

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[14] Imbroscio, *Reconstructing City Politics: Alternative Economic Development and Urban Regimes*, (1997), 162.

[15] Imbroscio, (1997).

[16] Feenberg, Andrew. *Questioning Technology,* (1999).

are able to test new ways that conservation technology and behavior can become part of social practice. While many of these codes are voluntary, some water codes, such as outdoor watering restrictions become mandatory. According to Feenberg, this signals that the citizens and social institutions recognize that the new code should be a resolved practice.

Market Determinism:

Market determinism holds that aggregate economic decisions determine future conditions. In its extreme forms, market determinism relies on the commensurability of all tangible things, such as land, and intangible things, such as human values. Wendy Espeland's study of the construction of dams for the Central Arizona Project evaluates some of the pitfalls within market determinism. In her book, *The Struggle for Water*, she describes how project managers for the proposed dams were unsuccessful at convincing the Yavapai Tribe to sell their land for $40 million so that Arizona could secure more water supply for, amongst other things, expanding desert cities and cotton farming. The very un-wealthy Yavapai resisted many offers because they perceived their land as something beyond their ability to sell, which is partly attributable to their beliefs in what was tied to land – ancestry and sense of sacredness. Ultimately the Orme dam was not built, and instead another smaller dam was built elsewhere, and an existing dam was modified to increase its capacity.[17]

Garret Hardin provides a market-related narrative explaining the difficulty of managing commonly held resources within his article “The Tragedy of the Commons.”[18] Hardin noted that commonly held resources, such as water, are difficult to manage because individuals may have more of an incentive to use as much of the resource as possible than to use a fair share that will allow for a sustained supply of the resource. Hardin mentions several ways of preventing the abuse of this resource, including privatization and regulation. While the relevance of this narrative is more renowned for groundwater conflicts in Texas, it is also appropriate for the City of Austin’s water and water system. Texas surface water managers have to balance regulating the private use of water with the need to maintain a resilient water supply system for the public as a whole. Water conservation specialist Alex Yager describes this conflict in Texas as a commodity vs. resource struggle. This struggle persists between those who frame water as a resource and those who vocally state that they “do not want to be told what to do.”[19]

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[17] Espeland, *The Struggle for Water: politics, rationality, and identity in the American Southwest,* (1998).

[18] Hardin, “The Tragedy of the Commons,” (1968).

[19] Yager, Alex. Interview, 2009.

Timothy Bartik describes several practices that allow municipalities to bridge this divide between public and private interests. Bartik's study *The Market Failure Approach to Regional Economic Development Policy*, while not originally aimed at utility policy, does describe several situations in which the market cannot provide services that would benefit both public and private interests. According to Bartik, the market cannot properly value communal goods, when the expense is too great for a single market actor.[20] Research, design, and public education represent types of services for which the market frequently cannot receive an adequate financial return to justify proper amounts of investment. Accordingly, municipal 'market interventions' are acceptable when externalized benefits elude the market but can be received by the municipality. When municipal interventions are successful, both the city, citizens and market actors should be able to benefit.

Following Hardin's theory, actors, such as private consumers, cities, markets and the public, use communally managed environmental resources for private benefit. Ultimately, Hardin holds, this process will continue to the detriment of the resource and actors relying on the resource. According to Scott Campbell this actor-network can be represented by a triangle of "conflicting goals for planning."[21] Campbell describes the interaction between competing actors as a series of three conflicts relevant to planners and city managers. These

[20] Bartik, "The Market Failure Approach to Regional Economic Development Policy" (1990), 362.

[21] Campbell, "Green Cities, Growing Cities, Just Cities?" (1996).

conflicts being: the property conflict, the development conflict, and the resource conflict. These three conflicts represent the struggle between economic growth, social equity and environmental health.

As discussed earlier, Regime Theory provides insight into how emergent coalitions can improve political equality that can develop as a result of these conflicts. Campbell's suggests that the actor-network can be balanced to achieve a healthy environment, profitable economies, and social fairness if social groups can resolve these three conflicts. The Conflicting goals of planning require the various actors and artifacts within city networks to identify common goals that solve their common problems.

These market theories do not hold that the 'invisible hand of the market' is paramount to social or technological influences, but rather part of a system that includes society and technology.

Technological Determinism:

Technological determinism predicts that all problems have technological solutions or that a specific technology will supercede other determining factors to solve a problem. (The Old Guard engineers' ideas described by Espeland, who believed that the construction of the Orme dam was the only solution to Arizona's water shortages, exemplify technological deterministic attitudes.) Through the committed efforts of many stakeholders, this claim was proven misguided. According to Merritt Smith, Americans became predisposed to technologically deterministic perspectives when the fledgling nation's sense of progress was infused with technological solutions during the early industrial revolution.[22] Popular and expert opinion throughout Austin's history have staunchly held that technology, especially water infrastructure systems, are a determining factor for a region's ability to grow (see Figure 1). While it is evident that this claim has much truth, Chapters 5 and 6 will show many situations were growth can occur with less water, or water infrastructure than deemed necessary by citizens and experts.

[22] Smith, *Technological Determinism in American Culture,* (1994).

Figure 1: Illustration of Technological Determinism: Austin's Growth and the Development of the Highland Lakes

Source: Austin Hisotry Center. *Austin American Statesman,* 31 January 1957.

Science and technology scholars such as Hughes, Winner, and Merritt Smith suggest that technology does not act as a independent force in society. Rather, technology is both socially constructed and an active influence on society. This soft technological determinism supports two key postulates for those seeking to analyze technology and society. The first postulate described by Thomas Hughes suggests that technological systems eventually can become embedded in society, and develop momentum, after which point they become very difficult to change. [23]

In *The Code of the City,* Eran Ben-Joseph shows how our current water-based method of disposing of sewage was not an inevitable design, but was socially-constructed. Water-based and pneumatic methods of disposing of solid waste were simultaneously developed and used successfully in many parts of the world.[24] In *The Sanitary City*, Martin Melosi shows how competing sanitary technologies were created and developed in various cities throughout the United States. In the middle to late 19th Century these technologies became working models for growing cities. The technologies' proponents cited health and sanitation concerns as reasons for developing these public water works.[25]

As cities adopted these technologies various layers of new infrastructure became extensively embedded. As the systems grew in size and necessity, society became extremely invested in their performance and permanence. Thomas Hughes' describes technological systems that have reached this level of integration as possessing 'technological momentum.' Technologies can become so embedded in our environment, culture, institutions, and planning processes that the ability to choose a new technological system becomes increasingly difficult.

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[23] Hughes, *Technological Momentum*. 1994.

[24] Ben-Joseph, 2005.

[25] Melosi, 2000.

The second postulate illustrated by Langdon Winner proposes two manners in which technologies can have politics. According to Winner, large technological systems such as centralized water and waste water systems can be interpreted as 'inherently political'. In *Do Artifacts have Politics*, Winner notes that some technologies, such as a bridge, may not have specific overt social or political value in their nature. However, these artifacts can be used for political purposes, as were the Long Island Bridges in New York. These bridges were designed with nine foot overhead clearances to keep busses, and more importantly the poor minorities that rode on them, off of Long Island beaches. However, Winner also notes that some technological systems are so large and complex that they have extensive political influence.[26] Chapter 5 will demonstrate numerous ways in which water-related infrastructure and programs have politics.

Another key debate related to technological determinism is the merits of distributed vs. centralized infrastructure. Decentralized technologies are typically associated with older water supply methods such as the travois, a horse and barrel method of distributing water, rainwater systems, and wells. Centralized technologies, on the other hand, are associated with the modern water supply systems represented by large water treatment centers and an extensive array of distribution pipes and pumps. The debate regarding the merits of these systems have more to do with agency, or who is in control of supervising reliability and

[26] Winner, *Do Artifacts have Politics,* 1980.

quality to ensure public health and safety than the actual location of the technology.

The reliance on terms such as centralized and decentralized (or distributed) infrastructure is problematic because centralized systems rely on a network of distributed parts, and often distributed systems have the same sources and key components, albeit at a different scale, as their centralized counterparts. Conservation efforts within the centralized system often focus on distributing new technologies to end-users to increase efficient uses of a resource. Replacing toilets, adding aerators, installing low flow shower heads, and adding moisture sensors to sprinkler systems, are all distributed technologies aimed at conserving water to maintain the resilience of the centralized system.

Like Latour, Merritt Smith argues that Americans are predisposed to make claims that artifacts, like actors, have their own agency, However, Winner and Hughes demur these claims. Instead they claim that artifacts' influence on society are limited to its embeddedness in both the physical world and our institutions. The degree of this influence can be great, especially for systems large enough to require the maintenance and supervision of multiple institutions and groups of experts. According to Winner, these 'large technical systems' become significant enough that, while they may not posses agency, they do represent and reinforce political and social values.

As will become evident in Chapter 5, throughout Austin's history technologically deterministic arguments are used as a rationale to pursue technological solutions for environmental, social, and, even, technological problems. As discussed by STS scholars such as Winner, Hughes, and Melosi, claims of technological determinism are in part false because they misrepresent the coevolving nature of society, technology, and the environment.

Conclusions:

While deterministic theories are an important part of describing our world, it is clear that one determining theory does not supersede another, but rather our world is influenced by multiple competing factors. Actor-Network Theory, Regime Theory, technological momentum, and market failure approach to economic development provide key tools that allow us to better understand how our world is shaped and conversely, how to empower ourselves, without excessive delusion, to change it. Merritt Smith has indicated that Americans are inclined to follow deterministic paradigms. However, these theories all suggest that the unilateral deterministic paradigms, when evaluated critically, are naïve. Instead of any one form of determinism superceding another, a group of theories have emerged that all suggest an integrated relationship between social, technological, and economic factors. Actor-Network Theory is particularly relevant because it not only readily integrates the social, technological, and environmental as actors and artifacts but also is interested in the relationships between these agents and artifacts that create the network. To this degree it serves as a useful lens to explore each of these paradigms.

Actor-networks provide a framework for exploring the relationship between citizens-consumers and institution-producers established in my hypothesis. As I will show later through the history of Austin's water infrastructure, Austin's leaders supported technological improvements throughout its history and argued that these technologies would help realize a future vision of Austin. In part these technologies have helped create a more economically diverse and urban Austin envisioned by some Austin citizens. It is also clear that these technologies have been framed by both the City of Austin and advocacy coalitions in ways that have produced regrettable social arrangements and environmental problems. The actions and impacts of innumerable actors and artifacts have maintained and adapted the network of the social and technological into an extensive network. This contents and relationships of this network will be explored through the analysis in chapter 9.

Social theories about code making, urban regimes, and actor-networks provide a framework for interpreting the findings throughout this thesis. Actor-networks present an important way to evaluate the validity of the hypothesis as well as reach additional conclusions about water conservation networks in

Austin. Code making, urban regimes, and the tragedy of the commons provide a framework for interpreting the data from each strategy, but in particular the qualitative strategies.

Chapter 4: Background

Introduction:

The findings in Chapters 5-8 exist within the larger social and environmental contexts. Geographic, regulatory, demographic, and climatic background from England, the United States of America, Texas, and Central Texas are necessary to frame Austin's water conservation program successfully. This chapter will cover these influences in narratives under the headings: *State and National Context,* with a focus on *Water Planning.* This will be followed by a discussion of the *Geography, Demographics,* as well as *Climate and Water Use* that influence the *Central Texas Context.*

State and National Context:

The history of water rights in Texas is long and interesting. Texas separates water rights into surface water and groundwater rights. The state's water law is mostly a product of English common law and water law from western American states.

Groundwater, also referred to as percolating water, is legally differentiated from surface water if the water is underground and does not move in distinct channels but rather is filtering through the earth. Texas water policy has stated that since groundwater is mysterious and occult it is difficult to regulate. The State of Texas has followed English common law, known as the Rule of Capture, for groundwater regulation within the state. The Rule of Capture gives landowners relatively unrestricted rights over any water under their property. While much has been learned about relevant geology and hydrology that effects groundwater, it is still difficult and expensive to know what exactly is happening underneath the surface. Since the burden of proof that underground water is in a distinct channel lies with the State, most underground water is, in effect, available through the Rule of Capture. State groundwater laws do not limit the quantity of water that can be pumped or the reasonableness of its use, and neighboring landowners may legally pump the other’s well dry. For this reason the law has also become popularly known as the ‘law of the largest pump’.

While the City of Austin does not use groundwater as a primary source of water, the strong property rights attached to it are an important part of Texan identity that affects how many residents frame resources. The State encouraged the creation of Groundwater Conservation Districts to voluntarily manage groundwater resources. While some of these entities have few real powers, others, like the Barton Springs/Edwards Aquifer Conservation District near Austin, have created enforceable conservation rules.

Surface water legislation was also originally borrowed from the English common law ‘Riparian Doctrine’ in 1840 when Texas was still an independent republic. Riparian rights are surface water rights granted through common law to parcels of land adjacent to a surface water system. These rights were attached to the land grant itself and generally allowed the non-consumptive use of the water, not ownership of the water itself. Water users had consumptive use of the water for their own 'natural wants.' At different times the law has stated that irrigation both is and is not a 'natural' use.[27] Riparian rights eventually became absorbed into appropriative water rights in the Twentieth Century.

The 'Doctrine of Prior Appropriation' was developed in Western mining states as a means to make claims to water rights in the absence of a government presence. This allowed speculators in need of water resources the ability to appropriate the water, or take it for their own use. Appropriative rights allow for the consumptive use of water and are not directly tied to a piece of land. Texas adopted modified versions of appropriative rights in 1889 for arid parts of the State, and in passing the *Irrigation Act of 1895* adopted it for the entire State.

Through the *Irrigation Act of 1913* the Texas legislature modified Riparian law so that rights were only valid if granted between 1840 and 1895. This act also developed a permitting system for all appropriative rights in the State. For all intents and purposes the Riparian rights were absorbed into appropriative

[27] Texas Water Development Board, *Continuing Water Resources Planning and Development for Texas*, *Phase 1, Vol. 2* (1977), IV-4 – IV-13.

rights in 1967 through the *Water Rights Adjudication Act.*[28] The City of Austin acquires its water rights via this appropriative system managed by the TCEQ.

Water Planning:

In 1917 public pressure to create more water supply prompted the Legislature to issue a water conservation amendment to the constitution. At this time conservation meant retaining waters within the State before they were lost to the sea.[29] Water conservation was thus first used by the state to describe what is now called water development. It would not be until 1997, the year after a short hard drought, that the State Legislature would substantively promote water conservation as we understand it today through Senate Bill 1.

In the 1950s Texas experienced what has become the worst drought on record.[30] During this time 244 of the State's 254 counties were declared disaster areas. Afterwards the State created the Texas Water Development Board (TWDB). The TWDB is the primary agency for making plans and allocating spending to ensure that Texas has adequate water resources.

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[28] Jarvis, "Fundamentals of Surface Water Law" (2001).

[29] Jarvis, "Fundamentals of Surface Water Law" (2001), 1-2.

[30] The worst drought on record is referred to as the 'drought of record.' The States records go back to 1895.

From its inception till around the 1980s the primary actions of the TWDB involved the planning and funding of reservoirs. Of Texas's current 196 large reservoirs, 86% were built before 1980.[31] There has been a major shift in the approach to developing water since the 1980s, from large structural solutions such as dams, to managing the existing systems more efficiently. New engineering solutions, such as desalinization and smaller infrastructure projects, have replaced reservoir construction as a preferred source of new waters. TWDB began requiring the submittal of water conservation plans with all loan requests in 1996. However, aside from this 'technical and planning support' the TWDB does not provide any funding for water conservation projects – it only provides funding for the development of new water resources.[32]

Since the 1960s, federal law began substantially affecting water and water-related infrastructure planning. The Federal Water Resource Planning Act of 1965 helped provide matching funding to the State for environmental and technical research and planning initiatives.[33] The establishment of the Environmental Protection Agency (EPA) through the National Environmental Protection Act (NEPA) in 1969, and the subsequent Federal Water Pollution Control Act and Safe Drinking Water Act in 1972 and 1974, respectively, created a watershed of new environmental regulation. These new laws put pressure on

[31] Texas Water Development Board, *Water for Texas* (2007), 110-113.

[32] Nillis, Chris *Interview* (2009).

[33] Texas Water Development Board, *Continuing Water Resources Planning and Development for Texas*, *Phase 1, Vol. 1*. (1977),1-17–1-23.

the City of Austin to balance both environmental concerns and strong growth pressures. The outcome of this tension developed into infrastructural chaos and the support for new policies and programs to protect the City's ability to manage its centralized water and wastewater distribution services.

Central Texas Context:

Austin is located within a five-county area referred to as Central Texas. The city itself exists almost entirely within Travis County, of which it has incorporated about a third of the area. While much of the relevant water policy will be mentioned in Chapter 5, it is important to understand key geographic, demographic, climatic, and water use details beforehand.

Geography:

Austin's geography includes two prominent sources of water. One of these sources is the Colorado River; and the other is a series of natural springs that are most noticeable on the west side of town. The springs occur partly due to a long series of small, inactive faults.

These faults and water features have important environmental and social implications. Environmentally speaking, the faults have caused a hilly terrain with thin soil to the west, and a flat terrain with thick soil to the east. The faults have also exposed many springs that occur in Karst hill country to the west.

The faults and river flows are at least partly responsible for the location of industry and poorer neighborhoods in the eastern part of town. This social, industrial and environmental development has created intense segregation and later gentrification for City residents. More recently the environmental sensitivity associated with the hill country and the relatively non-sensitive land to the east has shifted the priority for impervious development to the east. In the early 1990's the City created a Smart Growth Plan that integrated several development policies which decreases development restrictions in east Austin and supports stringent development restrictions in west Austin. (Maps of the City Smart Growth Plan and an analysis of the development implications of the City's impervious cover policies are included in the appendix.)

Demographics:

Central Texas will likely become part of one of the major metropolitan areas or megalopolises during the next 50 years. The Texas Water Development Board predicts that between 2010 and 2060 the population of Hays County will almost triple, Travis County will nearly double, and Williamson County will more than triple. This potential increase in population will create a demand for water that surpasses the current amount of water supply available to this region.[34] While the TWDB's predictions of water use for the State have never been lower than actual use, they have become progressively more accurate. Population predictions by the TWDB have been fairly accurate over their 50-year planning history. While it is difficult to know exactly what the future population will be, following past growth trends, which average 40% growth per decade for the Twentieth Century, support the planning board's estimated future population for the City (Table 2) These themes of growth and increased consumption of resources will be explored more during Chapters 5, 6 and 9.

Table 2: Population of Austin.

Year	Population	Percent Increase
1880	11,013	-
1890	14,575	32.3
1900	22,258	52.7
1910	29,860	34.2
1920	34,876	16.8
1930	53,120	52.3
1940	87,930	65.5
1950	132,459	50.6
1960	186,545	40.8
1970	251,808	35.0
1980	345,496	37.2
1990	472,020	36.6
2000	656,562	39.1
Average per decade:		41.1

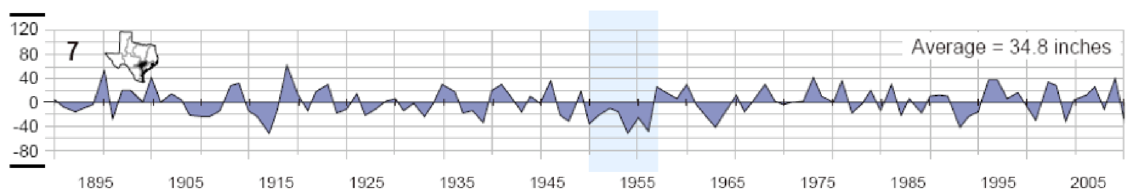
Source: U.S. Census.

[34] TWDB, *Water for Texas (*2007).

Climate and Water Use:

Austin is located towards the center of the State, and is on the cusp of arid and temperate climatic zones, making it at times wet and humid, and at times very hot and dry. Since Austin receives its water through rainfall within the Colorado River's watershed, precipitation is one of the most critical environmental conditions affecting the City's water management. As shown in Figure 2, over the last 100 years the Lower Colorado River region has experienced approximately eight droughts where only 70% of normal rainfall was received.

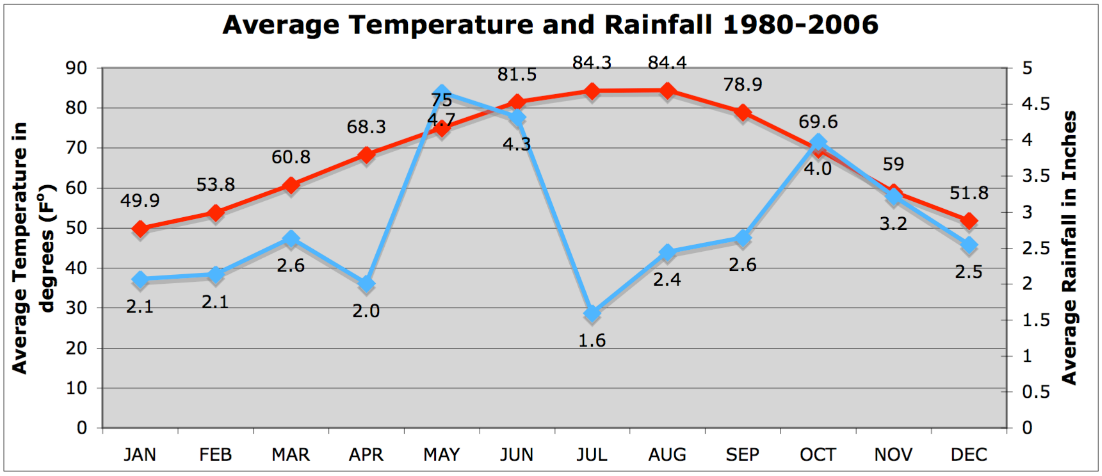
Figure 2: Graph Showing Rainfall as a Percenage of Histoirc Average.



Source: TWDB, *Water for Texas* (2007), 135.

Rainfall for Austin averages approximately 34 inches per year. When a drought occurs reservoir storage can drop to very low levels. As Figure 3 shows, the two months with the lowest rainfall are also the months with the highest temperatures. The combined effect of these two factors in a typical year influences customers' outdoor watering habits. Approximately half of Austin's water use is consumed for outdoor watering purposes.

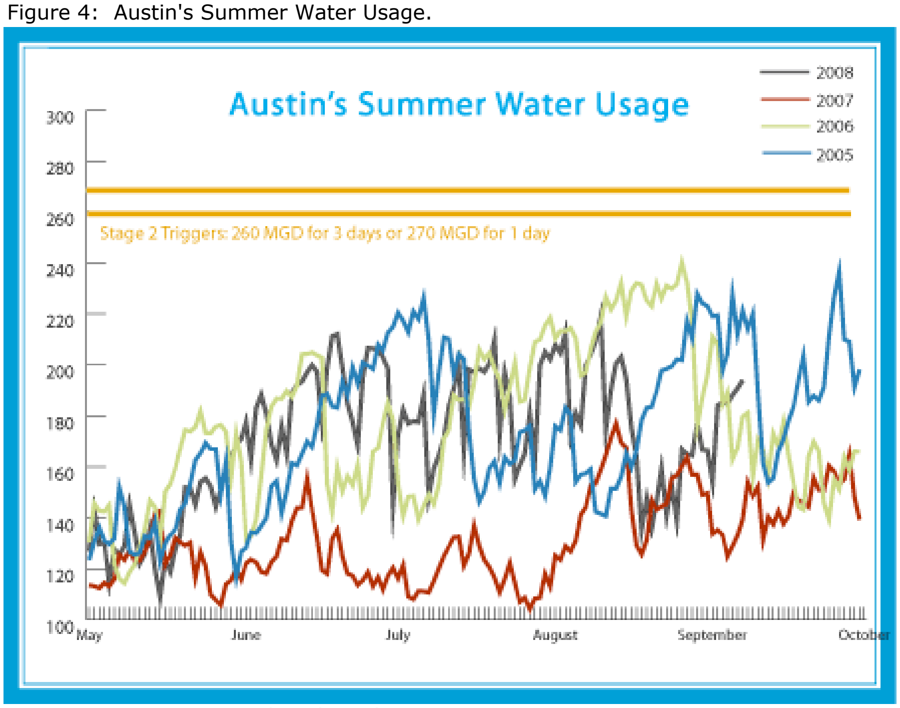
Figure 3: Average Temperature for Austin as recorded at Camp Mabry.



Source: NOAA.

Customers' higher water usage during the summer can stress City treatment and pumping infrastructure, as well as vegetation. Figure 4 shows how the combined environmental factors of the Central Texas summers effect peak water use.

Figure 4: Austin's Summer Water Usage.



Source: Austin Water Utility, (2009).

Approximately 36% of Austin Water's water sales go to residential water consumption. This is followed by 27% for commercial use and 21% for Multi-Family.[35] The relative trend of single-family residential water use from 1995 to 2006 is detailed in Table 3. The general trend is for a higher percentage of users to consume less water over this time period. However, water use for those who consume the most has tended to remain the same or increase slightly. Summer water use in 2006 indicates that the reduced water use is not likely due to abnormally low water use.

Table 3: Austin Single-Family Residential Water Consumption.

	Water use in Gallons per month.					number of users
Year	0-2,000	2,001-9,000	9,001-15,000	5,001-25,0	25,001 +	28,640
1995	2.8%	54.7%	29.7%	10.5%	2.4%	35,188
2001	3.4%	51.7%	29.7%	12.2%	2.9%	41,698
2006	14.8%	48.0%	22.5%	11.2%	3.4%	

Source: Water Consumption Data from Austin Water.

[35] Austin Water Utility, "Austin's 2007 Water Sales by Category" (2009). The other 14% are divided equally between Industrial and Wholesale uses.

Summary:

Austin is subject to a number of water planning laws at the state and federal level that influence its water management options. TWDB, TCEQ, and LCRA all influence water policy significantly. These influences provide Austin both environmental and demographic incentives to conserve water. These institutions, along with federal water quality standards, become important parts of the actor-network described in Chapter 5. The unpredictability of rainfall and the increasing regional population make water management planning a challenging endeavor. Technological solutions to these environmental and demographic problems have had mixed success over the years. These solutions are being heavily debated presently as Austin decision-makers and citizens search for opportunities to safeguard their water system.

Chapter 5: History of Water Infrastructure and Conservation in Austin

Introduction:

This chapter uses primary and secondary sources to create an in-depth history of Austin's infrastructure and conservation programs. *Part I, 1870-1970 Embedding Austin's Infrastructure* will describe how our modern system of infrastructure developed. Individual sections will cover: the distributed model; the private model; the public model; technological adaptation, Austin's pursuit of a resilient system; separate but equal planning; and Central Texas's modern reservoir system.

Part II, 1970-Present: Embedding Conservation will describe the emergence of Austin's modern conservation programs. Individual sections will cover: questioning development, 'pay as you go or tax and extend'; conservation, a distributed solution to centralized problems; and delaying future water infrastructure costs.

Conclusions will show how conservation has historically developed in response to infrastructure and water supply inadequacies. More recent support for conservation programs has come from the recognition of new costs, including the future cost of water and air quality regulations.

Part I, 1870-1970: Embedding Austin's First Infrastructure:

The Distributed Model:

The City's current water distribution system owes much to social, technological, and environmental developments around the turn of the Twentieth Century. The developments are in many ways congruent with national trends; however, since Austin is a younger US city, some of these developments occurred later than they did in larger, older cities.

Early inhabitants of Austin, which was founded in 1839, relied on rainwater harvesting and storage cisterns, wells, and surface water from creeks and the Colorado River for water sources. By 1867 it was noted that most families had cisterns, and some had both cisterns and wells.[36] A drought in the early 1870s found the City's more than 4,000 residents without a reliable water supply. During this drought, water was frequently delivered via a barrel pulled by horse – which was known as a travois, or commonly the 'Austin Lizard.'[37]

This use of distributed water systems is still common today. Rainwater harvesting systems and wells are still used in many communities around Austin. In general these communities are outside of larger municipalities and do not have access to centralized water systems. Since I did not find many specific stories

[36] Texas Almanac, 1867.

[37] Kent, "An Historical Review of Austin's Water Supply" (1988).

about rainwater and well-water users' experiences in the 1870s, I will explore the contemporary issues here to provide a description of how these technologies enable different choices.

Due to the unpredictability of underground water levels, many present day well-water users in Central Texas have switched to rainwater. The development of rainwater systems in this manner contradicts assertions by many individuals and institutions that rainwater systems are not viable. Banking institutions may only let homeowners with rainwater systems refinance their mortgage if they can prove an alternate source of water, or produce a contract that will ensure their cisterns will be filled by a third party during times of drought. Institutional preference for groundwater systems, which reportedly don't require proof of reliability, suggest that an institutional bias exists for groundwater systems, and against rainwater systems. This bias is likely because wells and centralized systems have managed to remain embedded, or maintained their technological momentum, in our social systems as preferred technologies.[38] Austin's centralized system, even with its past failings, which will be discussed later, is generally a more reliable system than household rainwater systems. The trend to switch to rainwater systems contradicts the local institutional preference for groundwater systems.

[38] Rainwater Forum, 2007.

Rainwater harvesting systems in Texas have different politics than groundwater systems because they enable different opportunities and challenges. Rainwater systems give users access to water in proportion to their roof size, rainfall, and storage capacity. Well-water systems give users access to generally unrestricted amounts of water but with no protection from how much other nearby users consume. While it might be easy to conclude that rainwater is more egalitarian than well-water, the different systems aren't just about different technology. The difference is also about social arrangements. The laws that govern groundwater generally allow users to pump as much water as they like. Thus, these technologies themselves are not by nature political, but can be interpreted as political objects.

The Private Model:

To create a more reliable water supply system after the drought of the 1870s, the City entered contractual arrangements with the privately-owned Austin Water Power and Light Company.[39] This contract, which was signed on January 10, 1876, allowed the Water Company to provide water for municipal and private purposes.[40] The franchise agreement between the City and the water company was mutually beneficial. Not only would some private residents have access to piped water, the City also negotiated the purchase and installation of more than a hundred fire hydrants, free water to public parks, and 15 free public watering troughs. The pumping capacity at the time was 3 million gallons per day (mgd).[41]

While we currently think of piped water and sewer systems as two parts of the same coin, it was not always that way. Integrating water and waste water functions did not occur within Austin's private industry model. While piped water in homes could facilitate wastewater systems that carry away human waste, sewer systems were not developed in conjunction with water supply services at this time. As was common for most contemporary cities, these services weren't

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[39] Also frequently referred to as 'the Water Company.'

[40] The Austin Water Power and Light Company was commonly referred to as the 'Water Company'. Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973).

[41] Kent, "An Historical Review of Austin's Water Supply" (1988), 12.

integrated in Austin for more than thirty years.[42] By 1880 the City Council recognized that it would not develop its own sewer system, and passed an ordinance allowing federal, state, and county entities to establish their own systems. Citizens were allowed to connect to these lines; however, few had the means for such an expensive connection. In 1882 the City allowed Brush Sewer Company to develop sewage systems in Austin. In exchange for this contract, City properties would receive free sewer services. The conditions set by the Council did not encourage or even allow many citizens to connect. Not only was the maximum rate set as high as $250 per building, but also the sewer company was exempted from servicing certain sections of town it deemed 'technically challenging.' As late as 1931, two minority neighborhoods, Wheatsville and Clarksville, had not received any sanitary sewer service, despite their relatively central locations.[43]

In 1882 the City allowed the Water Company to install and maintain electrical infrastructure.[44] The emergence of an electrical service in the City provided competition for public lighting, a service previously provided mostly by the 'Austin Gas-Light and Coal Company.' The competition between these street lighting technologies was later won by the Water Company, when, in 1887, it was

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[42] Melosi, *The Sanitary City* (2000).

[43] Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973). Mayoral Annual Report "Map of Sanitary Sewer Construction 1928-1930." (1930).

[44] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980).

awarded a contract to provide extensive electric street lighting and power for street cars. After this point, the electrical distribution system for lighting became so embedded throughout the city it would nearly become the sole provider for future public lighting.

The private model allowed the City to offer new services to city departments and some citizens alike. This public-private arrangement seemed to work well for the time. The sewer and water systems remained relatively separate. City officials during this early period regarded sanitary sewer connections as a luxury; later to be seen as a privilege, and eventually, by the 1920s, a necessity for public health. As will be explored in the next section, the City eventually purchased the water and sewer system. However, the ability to purchase these systems, as with many cities in America, was restricted by Austin's financial health. For these reasons Austin did not begin purchasing the private sewer systems until 1912, nor fully acquire the system until 1928.[45]

The decision to choose specific technologies, such as lighting systems, was influenced in part by the City's and citizens' satisfaction with the quality of service provided. Once large contracts to supply lighting via electricity were granted, this method of lighting became so embedded that it became the dominant 'centralized' lighting system.

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[45] Melosi, *The Sanitary City* (2000), 74-79. Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973), 20, 135-137.

In the transition from a distributed model to a private model, Austin's water actor-network expanded to include new social contracts and technological systems. The introduction of electrical lighting by the Water Company and the city created an overlapping electrical actor-network that continues to influence decision making within Austin's water actor-network today. In the following sections, the City continues to deliberate which technologies should be used, and who should control them.

The Public Model:

The competition between gas and electric lighting is paralleled by the competition between public and private control of the water and electric service. By the late 1880s, nearly 15 years after the water service began to be supplied privately, a public debate occurred over the need to build a reservoir to create a larger water supply, protection from floods, and increasingly, to promote public health. At the time there were no major dams on the Colorado.[46]

The proposal to create a publicly-owned reservoir also included the creation of a public water and power utility. The creation of these public works and institutions was thought by citizens to be a way to draw industry to town,

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[46] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980). Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973)

and, like street paving, was seen as a way to make their home a 'real city.'[47] The debate was not only about the choice of what type of technology should be used to supply the city, but also about who should own the right to extend service, and thus collect fees.[48]

Mayor Joseph Nalle claimed to oppose the construction of the dam because it would burden the city with too much debt. Contradicting the previous mayor, J.W. Robertson, Nalle stated that the Water Company provided high quality water and electric services. City leaders used fiscal reasoning to debate the future of Austin's water and electric infrastructure. Many fiscal conservatives of the day wanted to adopt a pay-as-you-go policy for infrastructure development. This financial argument was commonly used during the recent six-year long depression, that had begun with the Panic of 1873. The pay-as-you-go approach is contrasted with a tax and spend policy that was becoming more popular around the country as municipalities sought ways to finance large infrastructure projects that require extensive design, materials, and planning. According to Melosi, an ever-increasing reliance on municipal debt, primarily through bonds, enabled massive service related infrastructure projects to be developed.[49]

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[47] Kent, "An Historical Review of Austin's Water Supply" (1988).

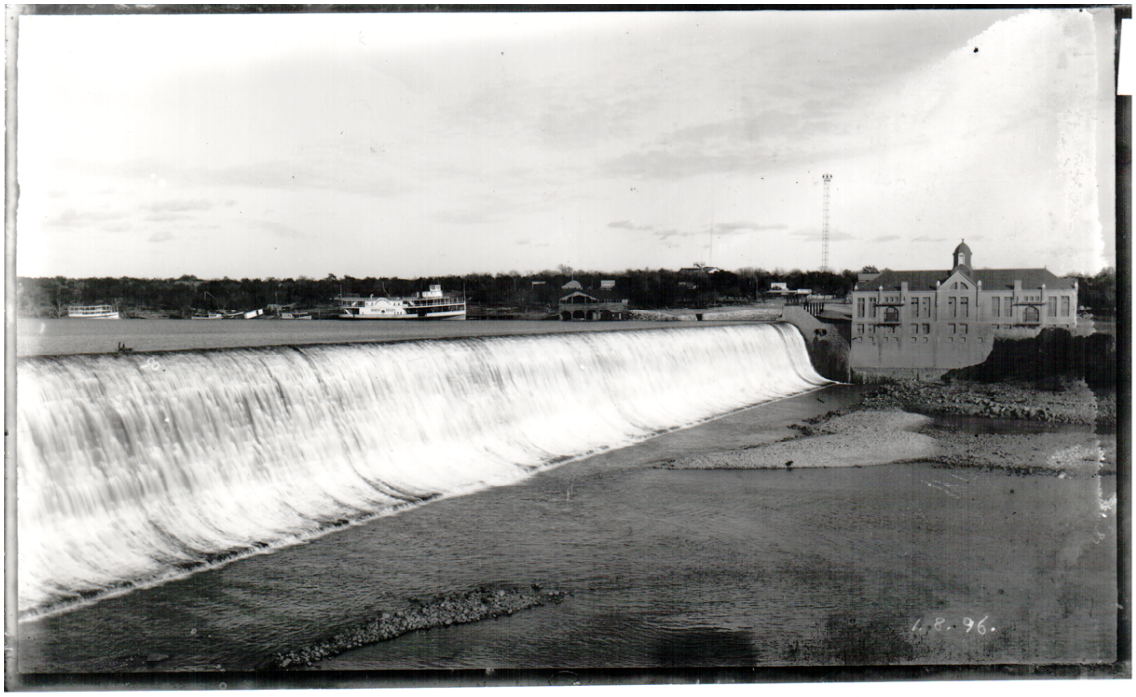
[48] Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973).

[49] Melosi, *The Sanitary City* (2000), 73-75. Kent, "An Historical Review of Austin's Water Supply" (1988). Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973).

Austin's mayoral election of 1889 helped decide whether the centralized water system would include a reservoir, and, additionally, whether it would be publicly controlled or remain in private hands. Mayoral candidate John McDonald, who supported building a dam and a public water utility, beat incumbent Mayor Joseph Nalle in a landslide election. Subsequently, the citizens of Austin supported McDonald's proposal in 1890 by overwhelmingly approving a $1.4 million bond election for the dam. That year the City made the first of several offers to buy the Water company, but were refused. Shortly thereafter, Nalle became the president of the Austin Water Light and Power Company. [50]

[50] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980).

Figure 5: The 'Austin Dam' and Power House, 1896.



Source: Austin History Center.

In 1893 the dam was completed and water and electrical power service began to be provided, (Figure 5). Disagreement continued between the City and the Water Company. The City Council commissioned a study to determine the quality of electric and water service provided by the Water Company. On July 3 1893, the council used evidence from their study to support a decision to pay the Water Company a reduced rate for the reduced efficiency of the services provided. In a reversal of their previous large investments in electric infrastructure, the Council awarded the Austin Gas-Light and Coal Company a contract to install 50 gas lights. This was done to rebuke the Water Company's services.[51] The conflict that precipitated from the City's decision to build a public system would not come to a close until after Water Company's investors took the City to the U.S. Supreme Court for breach of contract. The Supreme Court would defer to the lower courts ruling, which upheld the City's right to establish its own water works – despite the fact that this might devalue the bondholders' investment.[52]

Due to the City's financial straits, construction of the public water works continued in spurts. In 1894 Mayor Hancock didn't support the extension of public water lines, but did allow private citizens to pay for the extension of lines by themselves. By 1898, the city system would include 52 miles of water lines and 316 fire plugs.[53] The construction of the dam, water works, and placement of pipes was the primary public works project of the time. This left the citizens with relatively few paved roads – urban amenities that they were coming to expect. Aerial photos of the city at the time show a city with many unpaved roads, and many lawns around homes, (Figure 6). The lack of road paving and the existence of lawns led to an increase in citizens' demands for water. Krause's research into newspaper records discovered that the irrigation of unpaved streets was a common way for water users, who did not pay based on

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[51] Austin City Council Minutes, July 1st - 17th (1893).

[52] *Penn Mut. Life Ins. Co. V. City of Austin* (1898).

[53] Kent, "An Historical Review of Austin's Water Supply" (1988), 13.

use, to keep dust levels down. Similar statements from citizens corroborate the excessive use of water by sprinklers on lawns, which contributed to water pooling in the streets of Austin.[54]

Figure 6: South West View of Austin From the Capital dome. 1880's.

Source: Austin History Center.

By the mid 1890s the system would already be strained by the high water use during summer months. In 1896 the Superintendent of the Water and Light Plant, as the public utility was known, recommended that rates be increased to help pay for city services. Additionally the Superintendent suggested that billing customers based on metered water use would be more equitable for low water users, and would encourage water conservation. In 1897 Mayor Hancock addressed a special session of the City Council to better define what constituted

[54] Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973). "Using Lots of Water" *Statesman*, 7 July 1897

the 'waste of water.'[55] The ordinance passed by City Council prohibited water customers without water meters from sprinkling water anytime except between five to eight am and six to nine pm. The Mayor cited the need to prevent 'injury to the water pumps,' and to a lesser degree preserve a sufficient quantity of water in the lakes as reasons for this ordinance. Water conservation could relieve overburdened infrastructure and increase public access to water. At the time increasing public access to water was thought of as an important key to increasing public health in general.[56]

This transition from private to public was the product of various influences. Contributing factors for this transformation were the City's and citizens' desire to have more control over quality of services as well as cost of services, the belief that developing a reservoir would be an economic boon for the small city, and the belief that the City was better able to provide clean water which would promote public health. The enormous investment in public infrastructure was not pursued by the private providers who ran the Austin Water and Light Company. This may be partly because the company could not receive as much benefit as the public could from a dam's water surplus, (theoretical) flood protection, and increased health of the public. Melosi's account of water and wastewater services in America shows that Austin's actions were similar to national trends of the time. These trends sought to bring water and related services under public control to

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[55] City of Austin, Austin Council Meeting Minutes Archive. June 19th, 1896.

[56] Melosi, *The Sanitary City* (2000)

provide for growth and public health. The ability for cities to achieve this control relied partly on their access to capital.[57] Private companies also had access to capital, but, as will be seen throughout this chapter, they weren't as successful at completing these large projects. Investors understood that cities of the time were becoming a better investment, especially for projects that created these centralized systems which were predicted to help regions grow.

Joseph Nalle's regime, which argued for fiscally conservative pursuit of new technologies, did not survive. Austin's new coalition began to control infrastructure development throughout the City. This coalition envisioned a prosperous Austin that controlled its own resources, and it was willing to reach deep into bondholders' pockets to pursue this goal. Once endowed with its own system, however, Austin had difficulty maintaining control of it. This difficulty emerged from environmental, fiscal and water use challenges.

The relatively unrestricted use of water by citizen-consumers allowed common infrastructure resources to be mismanaged. The high use of water by public and private water consumers threatened the reliability of the system as a whole, including their own access to the resource. While the City presently has water meters and tiered pricing rates to influence water demand, the difficulty of managing public resources like water and infrastructure is still an important issue today.

[57] Melosi, 2000, pg. 75.

In this period Austin's water actor-network is characterized by the simultaneous expansion of public and private service providers. The coevolving systems of bonds, water treatment, water delivery, electrical distribution, and water policy have become established. In the following era the City of Austin must further adapt its system to environmental challenges and social pressure to more fully integrate water and wastewater services.

Technological Adaptation, Austin's Pursuit of a Resilient System:

In an April flood in 1900, water flowed a reported 11 feet over the dam and caused the dam to fail and break. The collapse of the dam forced the City to take quick measures. The City ordered steam generators to provide power for their water pumps and other electrical needs. Limited water service was restored by May 15th. Without the dam, the City now had a considerably more limited water supply. By September, water and electrical supply was available to most of the public system, including the street cars. Austin's public utility system now had been adapted to a system that closely resembled the private Austin Water Light and Power system.[58]

The demise of Austin's dam and waterworks often caused the frequent need for severe water rationing in order to have sufficient water supply and

[58] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980). Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973).

pumping capacity to provide Austin citizens with water. The public utility limped along as it slowly rebuilt its water and electrical infrastructure. Citizens were asked to comply with new ‘water waste’ ordinances, especially during the summer.[59] In June of 1901, The *Daily Statesman* noted that city water policy forbade the use of sprinklers, and stated that when watering “the hose must be held in the hand.” It was also reported that the water superintendent employed secret inspectors to pursue water use violators.[60]

In 1902 the City of Austin purchased the Austin Water Light and Power company for $1 million.[61] The acquisition of the company placed the control of both water and electrical service in public hands. The remaining energy systems, coal and gas, stayed in private hands. The integrated nature of the water and electric utility allowed the City to gain control of both systems early in their development.

In 1905, the Water and Light Commission withheld electric service from the City for a week to force the City to negotiate back payment of utility services owed to the Commission by the City itself. The Commission, which was created to provide technical oversight and management for the new public utility, exited negations with new oversight and approval powers for the new dam project.

[59] Water waste refers to water that is used in a wasteful manner, not ‘grey-water’ or ‘black-water.’

[60] “B. Hall may be abandoned unless water can be secured in the next few days. A squad of spies are to be sent out.” *The Daily Statesman*, 25 June 1901.

[61] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980).

Mayor Hancock was in favor of the new technical oversight and authority that he thought would balance the decisions made by the City Council. The commission did use these veto like powers twice to inhibit dam construction in 1907 and 1908. Eventually, by 1912 the mayor, City Council, citizens, Water and Light Commission, and the Johnson Company were all able to agree upon a contract to build a new Austin Dam.[62]

The new Austin Dam was completed on December 28th, 1914. Although the Dam had won the approval of many local interests, it couldn't withstand the torrential floodwaters to which Central Texas is prone. On May 1st, 1915 a devastating flood severely damaged the dam. While still partially functional, work to completely repair the dam would not occur for almost 15 more years.

The destructive floods forced Austin to adapt its system from one that relied on a large reservoir and hydroelectric power, to a system that had little water storage capacity and used primarily steam-powered electric generators. During this period between dams, Austin's population continued to grow at rates similar to its historic average. This suggests that the lack of a dam, and the relatively smaller system used between 1900 and 1915, did not limit the City's ability to support its population.

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[62] Austin Council Meeting Minutes Archive. May 24th, 1905. Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973).

As suggested by Winner, large technical systems such as dams and public works can be seen as inherently political technologies. The development of a powerful overseeing Commission to help maintain the system represents a social decision to create a hierarchal system of experts to maintain their water and electrical services. While the Water and Light Commission may have provided much useful advice for the City regarding how the City should develop its water and electric system, no evidence found suggests that the Commission tried to persuade the City that it would have continued difficulty trying to dam the Colorado River. Instead, the Commission appeared to be more concerned with who received the contract to build the dam, than whether or not building a new dam was a good idea. Of course, who builds the dam is important. However, the decision to build it or not is even more important. As will be shown in the next section, the completion of successful dams on the Colorado River will require a completely new financial, social and technological approach. Over the years, the City's building of dams on the Colorado diverted millions of dollars of public spending which could have been spent on other needed public works projects.

Actors within this water infrastructure network use public concerns such as health, economic prudence, social and infrastructural investments and equity to guide key policies and technological developments. The transition from distributed forms of water supply to centralized systems of water supply developed parallel to these public concerns. The urban growth regime that united to develop Austin's reservoir wanted to bring new technologies into society to help mediate environmental challenges. However, despite oversight from the expert-based Water and Light Commission, Austin was not able to 'control' the river and its environmental resources fully for many decades to come.

After the flood of 1900, Austin's water network was adapted to provide service without a fully functional reservoir and integrate the water works from the private Water Company. This adaptation process created a network with new overseeing agents that sought to keep both citizens and City Council on a course to maintain the resiliency of the water system. In the following era, the water network is framed by the City and Planners as a means to segregate the city.

Separate but Equal Planning:

On August 11th, 1927 the City Council passed an ordinance disallowing any other form of human waste management other than using the city sewage system for any residence with available sewage service. The ordinance allowed the use of fines as a means of enforcement. Shortly thereafter, in March of 1928, Koch and Fowler completed *A City Plan For Austin*. This plan included measures to segregate Austin by providing services for non-whites only in the eastern part of the city.[63] In the text of the 1928 Plan, Koch and Fowler make this intention clear:

> There has been considerable talk in Austin, as well as other cities, in regard to the race segregation problem. This problem cannot be solved legally under any zoning law known to us at present.
>
> It is our recommendation that the nearest approach to the solution of the race segregation problem will be the recommendation of this district as a negro district; and that all the facilities and conveniences be provided the negroes in this district, as an incentive to draw the negro population to this area. This will eliminate the necessity of duplication of white and black schools, white and black parks, and other duplicate facilities for this area.[64]

While the City could not force black residents out of their western neighborhoods directly, evidence suggests that they were able to do so indirectly by providing services in the negro district and charging stiff fines for those who

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[63] Krause, *Water, Sewers and Streets: The Acquisition of Public Utilities in Austin, Texas 1875-1930* (1973), 150-151.

[64] Koch and Fowler Consulting Engineers, *A City Plan For Austin*, Texas, (1928) – reprinted in 1957.

do not comply with the sewage policy. A November 1st article from the *Austin Statesman* in 1929, one week after the stock market crash, reports the sewage policy being enforced, with the potential effect of evicting people from their homes:

> Slowly but surely, with a little persuasion of the corporation court, Austin residents are connecting their house with available sewer lines.
>
> Violation of the ordinance is finable from $1 to $200, and each day constitutes a separate offense. If those cited in complaints are too stubborn, they are forced to evacuate their premises.
>
> "We do not wish to assess fines or drive people from their houses, but they must comply with the law." Judge Kone said.[65]

This ordinance shows how a city can use policy, specifically water and infrastructure policy, to control how the city develops geographically and racially.

While it can be important for public health reasons to have users connected to a centralized sanitary sewer system, policies can also be used as a tool of segregation. While previously minority neighborhoods, such as Clarksville and Wheatsville, did not receive sewerage service by the *private entities* that controlled the sewer lines, now minority residents were being forced by *public laws* to move out if they could not afford to connect to city services.

Engineers and City leaders decided to use infrastructure and services as a means of dividing the city racially. By doing so the city thought it could more easily provide separate but equal services upheld legally through Plessy V.

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65 "Residents tying up with sewer connections," *Austin Statesman*, 1 November 1929.

Ferguson in 1896. While sewer systems do not innately contain racial politics, the decision about imposing connection costs is politically divisive. Entitled white citizens, city institutions, and expert consultants were able to use the extension of, and connection to city services, to geographically impose segregatory values upon the city. The 1928 City Plan altered Austin's water network by explicitly framing its water service policy as a means of segregation. In Part II of this history, extension of and connection to water and sewer lines will be politicized again, and eventually, influence the City's need to start water conservation programs.

Central Texas' Modern Reservoir System:

As with the early water and light franchise, the private sector played a role in the development of water and energy works in Central Texas. In 1931 a Chicago-based Utility company's started to build the Hamilton Dam, later to be known as the Mansfield Dam, but failed before completion. This allowed lawyer and politician Alvin Wirtz, the appointee of the bankruptcy assets, to seek federal funding to complete the dam project. Strings attached to this federal spending required the money go to a "public agency created and owned by the State of Texas."[66] Wirtz used the Tennessee Valley Authority as a model for the development of the Lower Colorado River Authority (LCRA) – which was created

[66] LCRA "History", (2006).

by the Texas legislature in 1935. This same year another torrential flood poured over the Austin dam.

In 1938 the City of Austin and the LCRA agreed that the LCRA would rebuild the Austin Dam, and in exchange the City would agree to buy $20,000 of energy a year for 30 years. The dam, now known as the Tom Miller dam, was completed in 1940 for a cost of $3.2 million.[67]

Between 1937 and 1951 the LCRA built 6 dams on the Lower Colorado. One of these reservoirs, Lake Travis, helps provide flood protection for Austin and other downstream areas. The other dams were designed to help manage the flow of water and provide water supply storage. In 1960 the City of Austin completed Longhorn dam, the last major dam on the Colorado river. This dam forms a constant level lake at the center of Austin. The primary functions of these dams were put to test right away. In the 1950s, Texas entered what would become its most widespread and devastating drought in the State's history. This drought was followed immediately by heavy rains that would have likely caused flood damages in Austin before the construction of the dams.

The history of dam building in Austin shows the City attempting the very difficult task of engineering and building a dam to provide water, energy and flood protection. Austin alone was not able to modify its water supply network to

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[67] City of Austin Public Information Department, *Historical Highlights of the Capital City of Texas* (1980).

withstand the environmental challenges posed by the Colorado River. However, Austin's and Texas' leadership were able to bring these developments to the area by advocating for the use of New Deal funding to build the Highland Lakes.[68] Political actors such as Alvin Wirtz, Tom Miller, James Buchanan, and Lyndon Johnson were key to developing this system, as well as its managing body, the LCRA.

The basic structure and types of technologies within Austin's present day water system were completed with the construction of the dams forming the Highland Lakes. Following Hughes' theory of technological momentum the new robust system of dams and its regional authority responsible for the system is now effectively embedded both physically and institutionally. Austin continued to develop its water and wastewater treatment facilities over the following years. Now, with the completion of Highland Lakes system, the largest and most complex technological components of Austin's current system were integrated into its network. Figure 7 diagrammatically illustrates the main technological components in this system.

The LCRA and a resilient series of lakes have emerged as an important actor and artifact within Austin's water network. Although it took nearly sixty-years to fully realize a secure and dependable water source, the Highland Lakes eventually did provide this and more for the Austin area.

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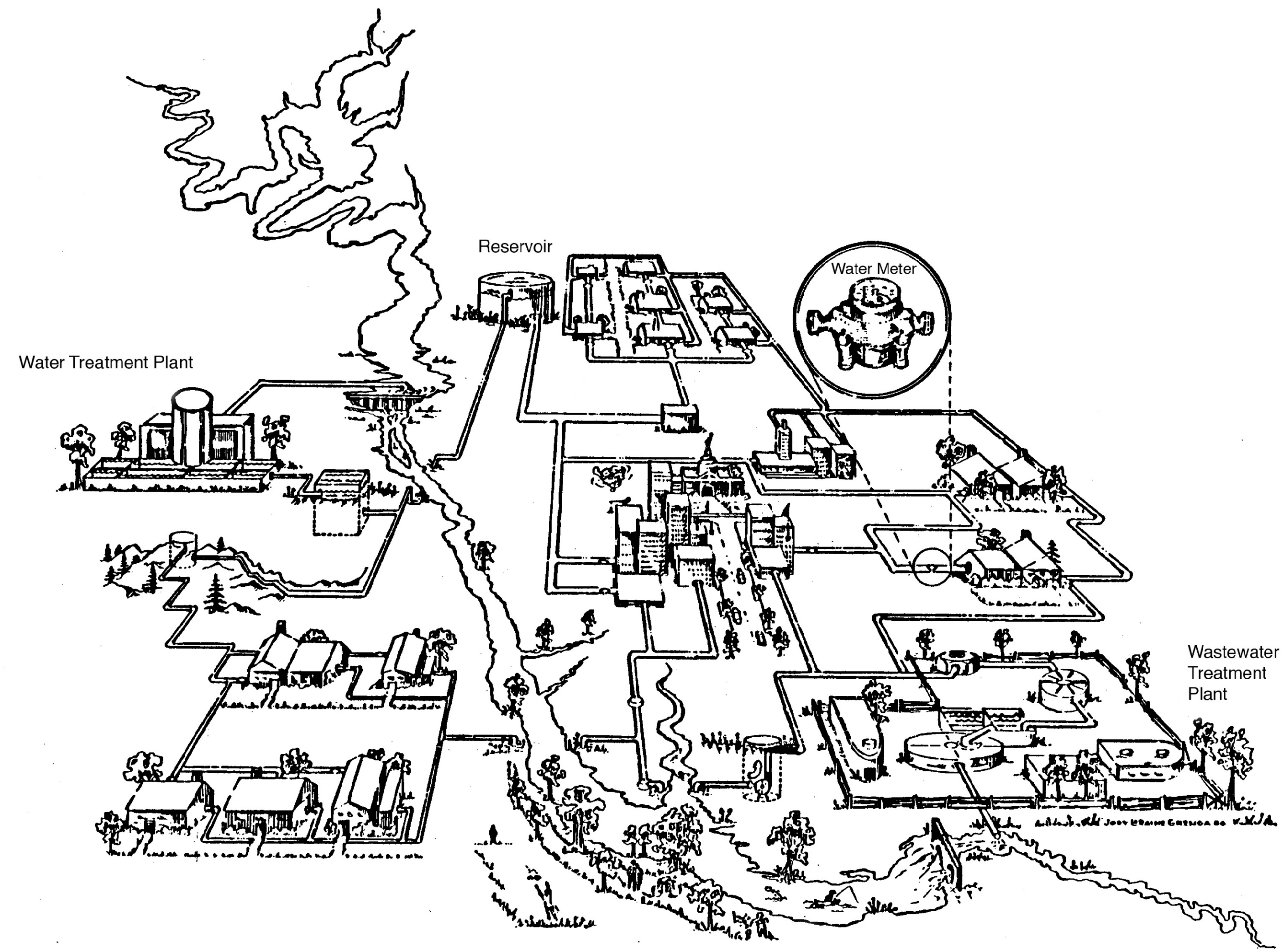
[68] Orum, *Power, Money & People: The Making Modern Austin* (1987). Moore, *Alternative routes to the Sustainable City* (2007).

In this period Austin's water network expanded as actors and water systems were created to provide regional water services at a regional scale,; these services include water security, flood protection, energy production, and supervision of the new large technological system. In summary, during this first period Austin's water network evolved from a distributed network amongst individual households, to an increasingly complex centralized network of infrastructure and agencies. As will be seen in Part II, actors, such as the LCRA, City of Austin, and Austin Citizens use their position to influence the development and service area of the network.

Figure 7: Illustration of Austin's Water Infrastructure, circa 1970



Source: Austin History Center.

Part II, 1970 - Present: Embedding Conservation:

In Part II, Austin's water network institutionalizes water conservation practice in an effort to maintain the water system that faces increased demand from the City's rapid growth.

Questioning Development: Pay as you go, or tax and extend?

By the 1970s, Austin and the surrounding area had entered a development boom that brought in new people to the area and changed the character of Austin. At the center of this development was the provision of water and waste water services. However, as citizens began to see rising rates in their services they also began to criticize the development, its environmental impacts, and how the costs of new development are shared. Applications for water and sewer connections more than doubled from 1,349 between 1969-1970 to 2,785 between 1970-1971.[69]

With this population and development boom, anti-growth and managed growth movements became vocal around Austin. A 1970 Austin League of Women Voters study tackled the issue of subsidizing development and found that Austin subsidized the cost of new development more than other cities of its

[69] "City's Water Usage in April Breaks all Previous Highs," *Statesman* 7 May 1971.

size. They recommended that the City revise its rebates and policy for development. They cited that these policies had been created to meet the post-war growth in 1946, and such incentives were no longer necessary.[70] These voices were countered by pro-growth voices from around Central Texas. In November, seven months after the League's study, the Texas Water Quality Board (TWQB) Executive Director Hugh Yantis publicly encouraged the City to take on more regional responsibility. Later in 1973, Yantis would make tentative proposals for a regional sewer system for the Austin-Travis County area.[71] The *Statesman* newspaper reported Yantis' position regarding Austin's role in regional development clearly:

> Austin has got to start understanding that it is the core city and it is going to be called upon to provide services in a way it never has done before. This is the first time Austin has had to face this question (of regional planning) squarely.[72]

Austin was well aware of the effects of their Water-Sewer policy on growth; however, it did not know how to respond to growth. City Manager Dan Davidson described the City's extra-territorial water policy as a determining factor for "the pattern and quality of Austin's future growth."[73] At the same time that Austin was attempting to redefine its role as a regional water provider, the water

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70 Austin League of Women Voters, "Subdivision Refund Contracts: Water-Sewer Rebates," (1970).

71 "TWQB Postpones Area Sewer Issue," *Statesman* 11 July 1973.

72 "Sewage Service Needs Here Cited," *The Daily Statesman* 13 November 1970.

73 Fowler. "Water-Sewer Policy Due," *The Austin Citizen* 6/26/1973.

utility was required to reexamine its rates due to both a court order and the energy crisis of 1973. The rise in energy prices prompted the Electric Utility to reconsider its subsidization of water and wastewater utility projects.[74] The Water Utility commissioned a study to adjust the rates incrementally so that it could begin to fund its own expenses:

> As requested, the minimal rates included herewith were developed to reflect an interim step toward establishing the water and wastewater utilities on a self-supporting basis. The rates would not meet all coverage requirements for issuing additional bonds, but would reduce the amount required from the electric utility to finance other utility operations.[75]

Some Austin residents resented having to pay higher utility charges that resulted from these rate increases. Austin voters repeatedly denied Council requests for new water-sewer utility financing. At four bond elections between 1975-1981 voters opposed $178 million in water bonds and $141 million in wastewater bonds, and only approved $32 million in water bonds and $47 million in wastewater bonds.[76] These rejections showed citizen disappointment in the Water Utility's rate changes and assistance in promoting un-managed growth.[77]

This conflict between the Utility's perceived obligations to provide services to new development clashed with citizen's perceived duty to rein in unfair spending. This conflict was not readily resolved and the City's promises to

[74] Fowler, "Water, Sewer Face Hike," *The Austin Citizen,* 27 November 1973.

[75] Black & Veatch, "City Water Rate Proposal", (1974).

[76] City of Austin, Clerk's office, Election History.

[77] "Proposed water Bonds Provide For Growth," *The Daily Texan* 9 August 1976

provide services without new infrastructure bonds created an infrastructural deficit that required the city to find new ways to increase its water treatment capacity.[78] Due to city attempts to create a multimillion dollar slush fund between 1976-79, the Sierra Club called for oversight of the Utility by a Water and Waste Water Commission (WWWC). This Commission was eventually created in 1981, and was "empowered to review, analyze, and advise the City Council on the policies and resources relating to the city water and wastewater utility and water quality."[79]

While the WWWC did provide oversight, it could not help the Water Utility fund needed infrastructure. By 1982 the Austin Neighborhood Council (ANC) claimed that the Utility was attempting to *legally* sell $50 million bonds without voter approval. The ANC perceived the Utility's extension of services as a catalyst for "unplanned growth" which would "allow damage and deterioration of the present water service" and cause "significant decrease in the quality of life in Austin."[80]

Austin's public growth vs. managed growth conflict would eventually call for the Utility to recommend a moratorium on the subdivision process in 1982. Prohibiting new subdivisions through a moratorium would prevent new water and

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[78] "Sewer system near capacity," *Statesman,* 20 May 1982.

[79] Water And Waste Water Commission, (2009). Laura Tuma, "Sierra club raps multimillion slush fund," *The Austin Citizen,* 18 September 1979.

[80] Douglas McLeod, "Coalition decries plan to fund growth without voter approval," *Statesman*, March 3rd 1982.

wastewater connections from being added to Austin's network. Such moratoriums were later realized as bans on new water or wastewater connections by 1984.[81] However, even with the $274 million in water and waste water bonds passed in December of 1982, the delay in expanding water and wastewater infrastructure was already significant enough to cause serious problems for the quality of the Utility's wastewater effluent in the years to come.[82]

During this period citizen-based groups in Austin began to challenge the mainstream development coalition in Austin. The activities of these groups revised the local actor-network and partially succeeded at hindering the dominant growth-based coalitions control of the development agenda. As we will see in the next section, by under-funding water and wastewater infrastructure improvements these groups were able to slow rapid connection of new homes to the City system. The creation of the Water and Wastewater Commission parallels the earlier Water and Light Commission. This commission was supported by growth management groups asking for more oversight regarding water and wastewater planning.

Through Austin's history, water and wastewater connection policy slowly transformed from the private provision to some residents to the public provision

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[81] The Austin Opinion. "The identity Crisis of Austin's Water Utility: what role can it afford to play in growth management?," *Daily Texan,* 5 August 1982. "Temporary halt to Southside hookups… 560 sewer requests on hold," *Statesman,* 2 March 1984.

[82] Max Woodfin, "Water supply comforts Austin," *Statesman,* 28 April 1983.

for all citizens. Early systems were promoted to secure public health and also used as a tool to help racially segregate the city. Through the WWWC and bond elections, citizens were able to provide some control of the subsidization of growth and urban sprawl.

In this period Austin's actor-network expanded to include new environmental regulations and advocacy coalitions; however, while the number of actors and artifacts increased, the expansion of infrastructure became more difficult. The next section shows unintended consequences that occurred because of citizen-institution and regulatory conflict.

1983 - 1990: Conservation, a distributed solution to centralized problems:

The delay of developing needed infrastructure produced water and wastewater treatment inadequacies that threatened the effectiveness of the Utility's core water systems. On May 2nd, 1983, the Austin City Council passed the Emergency Water Conservation Plan in order to 1) reduce peak demand, 2) ensure an adequate and safe water and wastewater system, 3) provide sufficient pressure to fight fires, 4) provide customers the option of voluntarily reducing their water use, and 5) attempt to protect Austin's aesthetic qualities.[83] By the next year the Conservation Department distributed efficient water use plumbing

[83] City of Austin. "Emergency Water Conservation Plan." 5/2/1983.

kits to citizens in an attempt to reduce indoor water consumption. These kits included toilet dams, efficient shower heads, and aerators.

The conservation efforts were not significant enough to meet Austin's wastewater needs. One month after passing out water conservation kits, the City of Austin was sued by the State for polluting its waters with wastewater effluent.[84] By August of 1984 the Austin Water Utility asked the Texas Water Commission (TWC) for permission to release 22 million gallons of partially treated effluent.[85] The TWC approved this discharge and would generally approve wastewater expansions over the next several years to help Austin reach a critical treatment capacity. However, the TWC did not give Austin a free pass to expand its services. In 1985 the State agency opposed 9,500 homes from connecting to the Austin Sewer System, and in 1986 it threatened Austin with $57,000 fines for non-attainment of pollution standards.[86] Surprisingly, even after needing to release untreated effluent into the Colorado, Water Utility managers blamed the Water Conservation program for its sagging water sales.[87] This battle of budgeting water sales for needed revenue persists between many conservation departments and their respective utilities today.

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[84] Dyer, Richard. "Wastewater problems tied to 1975 election: former city manager blames diverted bond revenues for Onion Creek delay," *Daily Texan* 7/17/1984.

[85] "Discharge of Sewage is Sought," *Statesman* 9 August 1984.

[86]. "Sewer decision to increase taps handed setback," *Statesman,* 23 January 1985. *$57,000 fine proposed for Austin violations of sewage plant orders*, *Statesman,* 4 June 1986.

[87] "City water sales seen as water conservation snag." *Statesman,* 2 September 1984.

During this time of nascent water conservation programs, the Conservation Division slowly developed a xeriscape program that was designed after similar programs existing in Colorado. As early as the summer of 1983, the conservation program began suggesting that residents landscape with native plants.[88] Other sources cite the origins of an official xeriscape program dating to 1984 or 1985.[89] The xeriscape program promoted landscape options using native and adapted plants as an alternative to thirsty turf lawns, which were by far the normal landscape choice for Central Texas residents.

The summer of 1986 was particularly difficult for Austin residents, who were watching the papers to see if mandatory watering requirements were going to be enacted. In July watering limits were enacted, and new summer water rates were proposed. The proposed water rates would charge a higher fee for water use that exceeded 130% of normal winter water use.[90] These water rates never took effect, and it would be another eight years before Austin would pass a tiered rate system to increase the cost of for those who use more water. The watering requirements would mainly be enforced on a voluntary basis as needed for the next twenty years.

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[88] "Switch to Native Plantings Advised." *Statesman,* 17 July 1983.

[89] ECSD. "How the Environmental and Conservation Services Department Came About," (1990). Gregg, Tony. City of Austin. "Water Efficiency in Austin," (2004).

[90] "Summer water rates proposed," *Statesman*, 18 July 1986. O'Malley, Sharon,. "Plan would reduce costs for low users," *West Austin News*, 25 February 1988.

Austin's Conservation Division continued its initial water conservation kit program in both 1985 and 1986 to help relieve the congested sewer system. In 1986 these kits were distributed door to door to target homes serviced by specific overloaded wastewater plants, such as the Govalle plant in East Austin. Austin Water Conservation's kit distribution program continued in some limited form until 1990.[91]

These events show how environmental and growth conflicts helped create a water conservation department to act as a growth management tool. This collection of water conservation programs can be seen as a water and wastewater conservation plant – much like Austin Energy's 1983 proposal for an energy conservation plant. Austin delayed the development of Water Treatment Plant 4, not just through conservation measures, but because of legal pressure from the LCRA in 1986. The LCRA questioned the City's right to draw water from Lake Travis to use in its proposed WTP 4. The disagreement between the LCRA and the City lasted more than a year and the negotiated agreement placed increased restrictions on Austin's ability to single handedly use water from Lake Travis for WTP 4.[92]

The unintended consequences of rejecting water and wastewater bonds resulted in the City's inability to maintain high treatment standards for their

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[91] Gregg, Tony. City of Austin. *Water Efficiency in Austin*. 2004.

[92] LCRA News, "LCRA Revokes Austin Permit" (11/26/1986). LCRA News, "LCRA and COA Reach Settlement" (12/10/1987).

wastewater effluent. It is not clear to what degree the conservation programs successfully aided the management of Austin's water problems. The emergence of water conservation programs appear to have focused on reducing indoor water use, which is treated both for drinking and wastewater purposes. Voluntary and mandatory watering restrictions were established as a way to help reduce peak demand at water treatment facilities. Winner's summary of how technology has politics is useful in understanding these developments.

The water network was modified through bond elections and citizen participation in conservation programs to create more participatory water management system. In this period Austin's water network can be characterized as integrating nascent water conservation policy. Citizens now had more options, limited as they were, to actively participate in the management of their water and wastewater systems.

1991-1999: Austin's Modern Conservation Programs.

In 1993, Austin received the results from a water conservation plan commissioned to suggest programs that would help reduce peak water use 10% by the year 2000.[93] The Montgomery Watson report detailed many potential

[93] Montgomery Watson, "Water Conservation Plan," (1993).

conservation programs that the City could adopt. Over the next 5 years the Conservation Division enacted some variation of many of the programs proposed by the report. Austin Water's Conservation Division continues today to give out inexpensive efficient indoor fixtures at public events. In 1993, the Conservation Division began both an irrigation audit and a toilet incentive program.[94]

The Environmental and Conservation Services Department lists a landscape audit and xeriscape program dating back to 1988.[95] The irrigation audits developed through the Environmental Department and the Montgomery Watson study provided technical assistance and education to help customers learn how to use and maintain their irrigation system properly to reduce water waste. Participating customers could receive up to a $150 credit for making recommended technological upgrades to their existing irrigation system, or by following design recommendations for a new system.[96] By 2002 this program would be limited to water users who used 25,000 gallons a month or more during summer months.[97] Limiting the program in this way helped the utility focus on high-use customers where they had the best chance of reducing water use.[98]

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[94] Gregg, "Water Efficiency in Austin," (City of Austin, 2004).

[95] ECSD, "How the Environmental and Conservation Services Department Came About," (1990).

[96] Gregg, "Water Efficiency in Austin," (City of Austin, 2004). City of Austin Water and Waste Water Utility, "Water Conservation Rates," (1994).

[97] City of Austin Water and Waste Water Utility. "Current City of Austin Waterwise Programs." 2002.

[98] Booker, Nate. Interview, 2009.

Toilet incentives generally provided access to free and rebated efficient toilets. In 1993, when the program started, customers could receive a $40 credit if they installed a 1.6 gallon per flush (gpf) toilet. By 1998 the program began giving away basic 1.6 gpf toilets for free, and offering $60-100 rebates for specific model of ultra low flush toilets. In 2002 the Conservation Division began giving a $30 rebate for customers that used licensed plumbers to install their toilet.

In 1994 AWU approved a tiered rate system for its water sales. Tony Gregg, the Conservation Division manager, also formally introduced Austin's Integrated Water Management Plan, which officially describes water conservation as a water demand management tool for Austin.[99] Also in 1994, the Conservation Division started its Xeriscape It program. This program gave up to a $240 rebate for the installation of native plants.[100]

In 1998, the Conservation Division started two new programs, the Wash-wise and Rainwater Harvesting Program. The Wash-wise program gave a $100 to $150 rebate for select models within three washer brands. This program uniquely included rebates from multiple types of utilities. If an AWU customer had an electric water-heater and service through Austin Energy they could receive a $150 rebate; if they used a gas water-heater and gas service through

[99] Gregg, Tony. "Austin's Integrated Water Planning Process." 1994.

[100] City of Austin Water and Waste Water Utility. "Water Conservation Rates." 1994.

Southern Union, they were eligible for a $100 rebate.[101] In 2002 the rebate for the Wash-wise program was reduced to $100 for all customers.[102]

The Rainwater Harvesting program started by giving up to a $500 rebate for customers who installed a rainwater system. The program placed restrictions on how the participant could use the water – rainwater use was limited to irrigation, pools, or ponds.[103]

In 1999 two influential studies helped inform the future of Austin Water Conservation efforts. A Water Price Elasticity study helped AWU understand how to structure their tiered rates to be fair to low water users, and effective enough to promote conservation by high water users.[104] The American Water Works Association (AWWA), published a study showing how residential customers use water. This study helped the Conservation Division target different users and better understand the effectiveness of their programs.[105] In 1999, Austin Water Conservation Division also published their final study of water conservation using native plantings.[106]

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[101] City of Austin Water and Waste Water Utility. "Water Conservation Rates." 1994.

[102] City of Austin Water and Waste Water Utility. "Current City of Austin Waterwise Programs." 2002.

[103] City of Austin Water and Waste Water Utility. "There will Never Be a Better Time…." 1998.

[104] Stratus. "Water Price Elasticities for single-family Homes in Texas." 1999

[105] Mayer, *Residential End Uses of Water*, 1999.

[106] Gregg, Tony. City of Austin. "Xeriscaping: Sowing the Seeds for Reducing Water Consumption." 3/31/1991

By 1999, the Conservation Division had begun subsidizing rain barrels as well. They provided a $30 rebate for up to four approved barrels. Additionally, customers were allowed to buy up to 2-75 gallon barrels from the City.[107] The price of the City barrels has changed over the years from $20, to $30, and finally $60.[108] The number of barrels allowed per account has changed as well. Now participants can purchase up to four City rain barrels. The city has since distributed thousands of discounted rain barrels.

In 1999, the LCRA and the City of Austin amended their water supply agreement. The amended agreements, which passed City Council by 7-0 vote, cost the city $100 million and provided water rights through 2050. The City financed it partially through the AWU budget ($27 million), and partially through issuing 40 year revenue bonds to allow future water users to pay for their water.[109] In the agreement the City maintained its state approved right to withdraw 150,000 af/year without charge, and additionally the City pre-paid for the right to withdraw up to 201,000 af/year at a cost of $105/af. However, the contract stipulated that after the city has withdrawn 210,000 af/year for two consecutive years it would begin to pay the LCRA market rate for water use over

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[107] Gregg, Tony. City of Austin. "Water Efficiency in Austin." 2004. City of Austin Water and Waste Water Utility. "Current City of Austin Waterwise Programs." 2002.

[108] Booker, Nate. Interview, 2009.

[109] Lindell, Chuck. "Austin, LCRA ink contract for water," *Statesman,* 8 October1999.

150,000/af.[110] The City and environmental organizations disagreed on the value of this agreement. Austin City Council Member Bill Spellman stated that "What we are buying here is not just water. What we are buying is control over our destiny." The Save Our Springs Alliance (SOS), a local environmental group dedicated to water quality and development issues, was hesitant to support the agreement. SOS speculated that LCRA would use the money to extend water lines into the Hill Country and allow sensitive areas to be developed.[111]

During the 1990s the water utility expanded the number of options in which citizen-consumers could reduce their water consumption. These new programs included increased ways of reducing water both indoors and outdoors. Studies conducted for Austin specifically and the nation as a whole allowed water managers to understand both the value of water and how effective they might be. Water conservation became officially recognized by the utility as an integral part of managing water demand. Conservation programs continued to be important because they delayed both the need for new infrastructure and the contractual obligation to pay the LCRA's increased market rate.

In this period Austin's water network can be characterized as a water system that integrates basic water conservation programs that seek to expand citizen efforts to control water demand.

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[110] Office of the City Auditor. Water Conservation I: Reliability of Water Savings Projections For Indoor Strategies. 12/12/2006

[111] Garza, Jesus. "Meeting needs takes planning," *Statesman,* 4 September 1999.

2000-Present: Delaying Future Water Infrastructure Costs:

By 2000, Water Treatment Plant Four (WTP 4) had been delayed for more than 15 years since the bonds for this plant were initially passed in 1984. On December 7th, 2000, Carollo Engineers presented a proposal to the City Council to build a new Green treatment plant on the same site in downtown Austin. The proposed plant would occupy 20% of the original facility's footprint, use a membrane technology and have a treatment capacity of 90 million gallons per day (mgd). The new Green Treatment Plant would cost just over $120 million.[112] The proposal was never approved. Some sources indicate that utility engineers did not believe the technology would work with Austin's current system. Environmental advocate Dylan Hackel, who vocally opposed the subsequent sites proposed for WTP 4, suggested that the Green proposal was not approved because the City was interested in developing a larger plant located at a site near Lake Travis.[113]

The proposal for WTP 4 located at Lake Travis initially was projected to cost around $300 million and produce 50 mgd with the possibility to extend the

[112] Carollo Engineers, "Green Water Treatment Plant Presentation," 7 December 2000. The Green treatment plant is named after Thomas C. Green, and does not refer to its environmental 'greenness'.

[113] Hackel, Dylan. Interview (2009).

plant to up to 300 mgd capacity. Current cost projections exceed $500 million. According to Hackel, Carollo Engineers likely went along with the City's proposal, not because of incompatible technologies as reported by City engineers, but because the project cost would bring them a much larger purse. Using Regime Theory to interpret Hackel's understanding of these events, Carollo is part of the land-based private interests that guide key planning and development decisions. For environmental advocates, infrastructure location is about the development of both the plant and future subdivisions near environmentally sensitive land.

According to Taylor Rainey, advocates of the City's decision to move the site near Lake Travis cite numerous reasons why the Lake Travis location is best. These reasons include: 1) it is the best topographic location, which would reduce the expensive and energy intensive source of water, and, 2) it has the best proximity to the cleanest and most abundant source of water. For the proponents, infrastructure is not framed just on considerations of future land development; rather, it is framed by concerns about water quality and energy conservation. Both environmental and City advocates recognize the cost effectiveness of water conservation and the need to delay WTP 4. They disagree about how long conservation can predictably delay the need for WTP 4, when the new plant will be needed, and how much more the City can reduce water usage through water conservation.

In 2003 a revolutionary study on toilets was published. In a consumer reports style study for municipalities, popular toilet models were tested for water usage and performance.[114] The study revolutionized municipal toilet replacement programs, which quickly began selecting toilets that performed well for their conservation programs.[115]

In 2004, the Conservation Division reflected back on the past 20 years of water conservation activities and published a historical accounting of the division's programs. "Water Efficiency in Austin" would later be republished in trade journals giving other cities exposure to some of Austin's lessons.

In 2004 a special Texas Water Development Board Water Conservation Task Force published the Water Conservation Best Management Practices Guide for Texas. This study gave municipal water conservation managers templates and metrics for measuring success. These metrics were developed to help provide insights for water conservation departments who were having trouble adequately assessing the water savings of their programs. Most water conservation departments interviewed for this historical study confirmed the extreme difficulty of measuring program success. This problem, some suggest,

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114 Gauley, "Maximum Performance Testing of Popular Toilet Models," (2003).

115 Booker, Nate. Interview, (2009).

is why conservation programs tend to focus on technological efficiency programs instead of habit or behavior programs.[116]

In July 2006, Alan Plummer and Associates finished two studies for the Conservation Division. The first was an evaluation of peak day water conservation strategies.[117] The second compared Austin Water's conservation programs with conservation programs in other cities in Texas.[118] They both were commissioned to help assess the feasibility of delaying the need for WTP 4 until 2012 or beyond.

In August 2006 the City Council asked the Conservation Division to put together a task force to examine how Austin Water might decrease their peak water use by 1% a year for 10 years. By the spring of 2007 the task force had completed its evaluation and presented several recommendations. The Austin City Council began passing some of these resolutions in 2007. Earlier in 2006, the City Auditor had reviewed the Conservation Divisions estimated savings from conserving water and found that "the process used to arrive at the calculated water savings projections would benefit from a more rigorous approach to developing information." The Auditor also noted that the division should make

116 Booker, Nate. Interview, (2009).

117 Alan Plummer Associates Inc., "Evaluation of Peak Day Water Conservation Strategies for the City of Austin: 2007-2015," (2006).

118 Alan Plummer Associates Inc., "Comparison to Other Cities," (2006).

historical water use data more available to users.[119]

One of the most important water conservation policies adopted by Council because of this report is an updated outdoor watering policy. On October 1st 2007 City Council amended the Water Use Management Ordinance that governs what is defined as 'water waste,' and how it can be enforced. This policy created permanent mandatory watering restrictions for all residential customers between May 1st to September 30th.[120]

Although not a specific recommendation by the Water Conservation Task Force, the Waterwise landscape program was discontinued. Experts familiar with the program cited a high cost-to-benefit ratio that made the program ineffective. In many cases people used more water after they installed efficient landscaping.[121]

The delay of WTP 4 is an important goal for environmental advocates and water managers alike. While environmental advocates are interested in delaying the plant to support water conservation practices, they also are interested in extending the debate about where the plant should be, how large it should be, when it should be built, and how much it will cost. Proponents of the current WTP 4 plan seem assured that the plant should be built sooner than later, that

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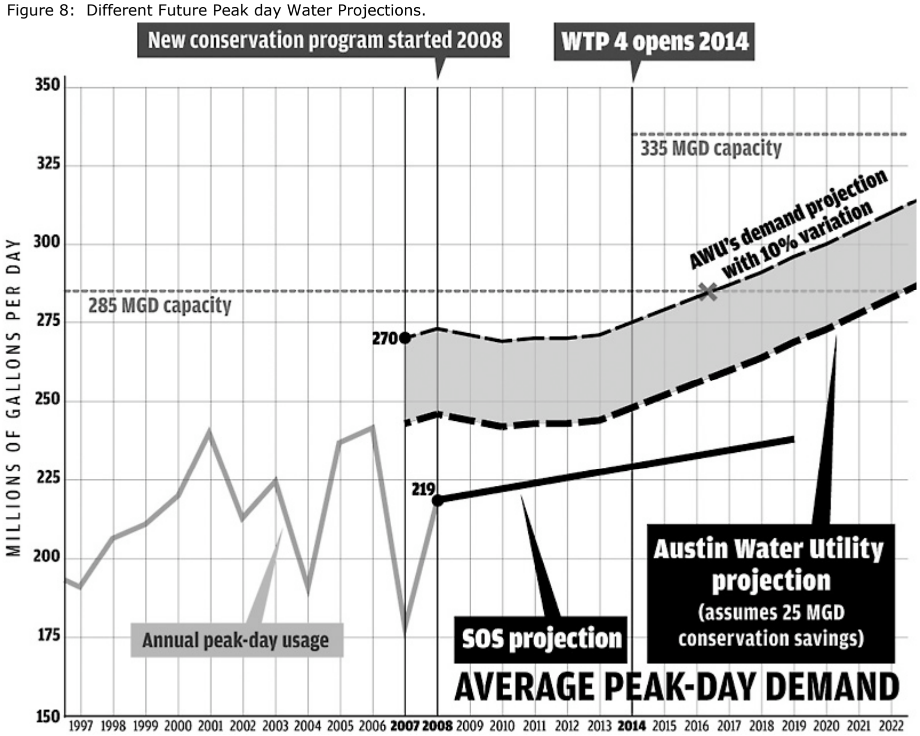
[119] Office of the City Auditor. Water Conservation I: Reliability of Water Savings Projections For Indoor Strategies. 12/12/2006.

[120] City of Austin. Chapter 6-4 of City Code. 10/1/2007.

[121] Interview Respondents familiar with Conservation Programs and Policy.

they have correctly estimated the reliability of conservation to assist in delaying the plant, and that it is sited appropriately. Figure 8 shows the different water-use projections, and expected timeframe for a new plant, for both the Water Utility and the SOS Alliance.

Figure 8: Different Future Peak day Water Projections.



Source: "Dumping the Pump," *Austin Chronicle*, 20 Feburary 2009.

These positions were re-iterated at a public forum held on September 17th, 2009. At this debate, the merits of WTP 4 were discussed by representatives from the Water Utility and the Environmental community. Environmental advocates interpreted the plant as an unnecessary and expensive boondoggle. Advocates for the City's plan interpreted the plant as an environmentally beneficial system upgrade that will increase the efficiency and reliability of the overall water system.[122] While this open public debate is rather unique in Austin's history, the polar representation of public decisions by the environmental community and Utility is similar to the 'public dialog' in the 1980s. On October 22nd, 2009, the Austin City Council approved an initial phase in building WTP 4. After 25 years of debate and planning this decision was widely regarded as the final decision to build WTP 4.

In this most recent period Austin's water network adapted to reflect new insights and regulation regarding water conservation as an integral tool in the development of its water system. Actors within this system were successful at adapting the role of conservation in the larger water network to pose serious consideration of the value of both water conservation and expansion.

Conclusions:

Austin has struggled with how to use infrastructure to help it grow since the City first began investing in private and public systems. Some conservation strategies were adopted early as a crucial tool to mitigate major infrastructure failures. Over the years water conservation programs emerged as an important part of Austin's water planning tools that allow the city to manage growth. Table

[122] Council, Austin City. *Special Meeting Water Treatment Plant 4 Forum.* 9/17/2009.

4 summarizes the progressive development of infrastructure and conservation in Austin.

Table 4: Historical comparison of Infrastructure and Conservation Development.

	Infrastructure Development	Conservation Development	Reason for Conservation
1890-1900	Invest in large reservoir and water works. Provide limited, more affordable access for some citizens. Spatial inequality of distribution.	Proactive suggestions for water meters by the Superintendent - they are used on a limited basis. Also 'Water Waste' is defined by Council proactively.	Peak Capacity and Water Supply.
1900-late 1920's	Keep Investing in Dam despite multiple catastrophic setbacks. Slowly extend service to some community members. Purchase Private system.	Reacting to the destruction of the Austin Dam mandatory water restrictions are instated and enforcement police are hired.	Critical Infrastructure Failure.
1984-1990	Denial of some Capital expenditures for water and waste water facilities.	Reacting to Infrastructure failures the Conservation Division is Established, Conservation Kits distributed, Water Management Policies Revised.	Peak Capacity inadequacy, especially of Wastewater Facilities.
1991 - 2000	Clean Water Program Initiated. Green Water Treatment Plant Closed.	Several Residential Water Conservation Programs are established - a proactive measure to overall water management.	Peak Capacity, Costs of Future Water, New State Conservation Planning Regulation.
2001 - 2009	Clean Water Program replaces miles of poor quality wastewater lines. Partial Construction of Water Treatment Plant #4 is approved.	Existing Programs are continued. Studies are used to guide new water conservation oriented codes. Water Wise Landscape reformed in the Watershed Department.	Peak Capacity, Costs of Future Water, Regulation, EPA Air Quality Attainment

The historical comparison of infrastructure and conservation development shows Austin Water Utility both using conservation more proactively as a planning tool, and that the Utility developed an increased reliance on programs to meet demand and regulatory needs. By the late 1990’s water conservation programs had become socially embedded in the Utility and other agencies across the State and Country. The list of reasons for conserving also increased from mere processed-gallons saved and infrastructure management, to include long term goals such future supply costs and costs of meeting future regulations. Chapter 6 and Chapter 9 will further explore how these future considerations are valued by utilities.

Studies and reports also played a key role in the development of water conservation programs at the City of Austin. The Montgomery Watson proposal of water conservation programs for Austin started a broad set of programs that continue at Austin today. Knowledge derived from later reports has been used to adapt the Conservation Division's approach to specific programs, as well as conservation in general. Table 5 lists many of the key studies used to aid in the design and evaluation of Austin's water conservation programs.

These studies are part of an educational process within the Utility's actor-network. The researchers and the institutions they represent become influential actors within Austin's water network. The purpose of these educational agents is to provide a way for the utilities and regulatory institutions to conserve and manage water more effectively. Conclusions from these studies are translated by utilities into educational programs for the public. While some studies provide insights into customer perceptions and behavior, no studies or surveys were encountered that show the Utility directly attempting to acquire better knowledge about the specific attitudes and perceptions of Austin Water customers. This indicates that the Utility may lack interest in how citizens-consumers frame water-use, and why they might be interested in conserving. The following chapter will continue examining the role of conservation at utilities, in addition to how they are designed and evaluated.

Table 5: Key Studies for Water Conservation in Austin

Researcher (Client)	Year	Object of Study	Area of Study	Impact of Study
Gregg	1991	Xeriscape	Austin	Unknown
Montgomery Watson (City of Austin)	1993	Water Conservation plan to Reduce peak water use.	Austin	Impacts Design of Austin's Water Conservation Programs.
Mayer (AWWA)	1999	How residential customers use water.	United States	Impacts design and evaluation of programs relative to Customer Use.
Stratus (TWDB)	1999	Customers response to increased water prices	Tri-City Area in Texas	Impacts design of tiered water rates.
GDS Associates (TWDB)	2001	Effectiveness, cost per gallon, of water conservation strategies.	Texas	Impacts evaluation of programs.
Gauley (22 North American Cities)	2003	Toilet Performance	North America	Impact design and evaluation of toilet programs.
GDS Associates (TWDB)	2004	Water Conservation Best Practices	Texas	Impacts program design for Cities.
Enviromedia (TWDB)	2004	Attitudes to water conservation	Texas	Impacts how programs are designed for customers.
Alan Plummer (City of Austin)	2006	Approaches to reducing peak demand of water	Austin	Impacts program Design for the City.
Alan Plummer (City of Austin)	2006	Comparison of Austin water use and conservation compared to other cities.	Austin	Impacts evaluation of Austin's commitment to water conservation.

The history of water conservation and related studies at the City of Austin show what Howard Davis might refer to as an evolving 'water culture.' The culture has changed from one that uses water and water infrastructure as a way to control city growth, to a more introspective look at the future impacts of the current water management process. These findings also document the changing actor-network. Important changes to and attempts to maintain the network include: the decision to start a private and public system; attempts to rebuild and maintain the dam after several failures; the creation of the highland lake system; the energy crisis' impacts on the Water Utility's financial model; the decision to deny and approve water infrastructure bonds; the creation of a Water Conservation Division; the proliferation of new water conservation knowledge; and the steady adaptation of conservation programs. The institutions, coalitions, infrastructure and policy that influence water development and conservation will be included in a revised Actor-Network model in chapter 9.

Chapter 6: Interview Findings

Introduction:

This chapter will present findings from the interviews covering topics that are more clearly presented in a separate context, outside of the historic narrative. The results will be presented as narratives that describe how water conservation professionals understand their industry. The first two narrative sections will describe *how experts understand participants and users*, and *how programs work*. The last three narrative sections will describe *conservation metrics*, *conservation as commodity*, and *framing conservation practice*. After these five narrative sections, I will draw conclusions from the various story lines. Interview questions are listed in the appendix. Pseudonyms and backgrounds of respondents are listed on the following page.

List of Interview Respondents:

Alex Yager: Water conservation professional familiar with regional water conservation issues and programs.

Chris Nillis: Water Conservation professional familiar with state and municipal policy, history and research.

Dominique Soloman: Water conservation professional familiar with Austin Water and their conservation programs.

Dylan Hackel: Environmental advocate familiar water conservation and development issues.

Jodi Aukum: Water conservation professional very familiar with programs at SAWS, as well as regional and national conservation activities.

Nate Booker: Professional very familiar with water conservation programs, history and research relevant to Austin.

Shannon Lavon: Conservation oriented professional familiar with city affairs, especially environmental policy.

Sidney Raab: Academically oriented professional familiar with city policy and history, with a special focus on water issues.

Taylor Rainey: Academically oriented professional familiar with city policy and history, with a special focus on environmental aspects of water issues.

How Experts Understand Participants and Users:

The professional respondents interviewed for this thesis drew on numerous sources to explain their understanding of customers, and program participants. Insights from the 2004 Enviromedia survey, written feedback, their own professional experience and one-on-one interactions were commonly cited sources. Professional rhetoric about customers and their involvement in conservation converge into two major themes: customer's awareness of water issues and willingness to participate.

Respondents frequently spoke of user's awareness of their water-use, and reasons for conserving water as determining factors for deciding to participate in conservation efforts. Respondents Chris Nillis and Alex Yager both mentioned that people don't know how much or how their water is used. Yager, expanded upon this comment by adding that water utilities don't do a good job of telling people how they use their water, making it difficult for people to understand where they might be able to conserve the easiest. Both of these respondents, along with Jodi Aukum, also remarked that most people think they conserve in some way. Those interviewed cited developing customer awareness around water issues as a way to increase water conservation related behavior. This reframing process can be effective for some, as both Aukum and Yager commented, because people would be able to identify where they might be wasting water - and they really don't want to waste. Howerver, while they don't want to waste water, they also don’t want to feel that they are going to have a reduced quality of life.

Professionals describe people who are likely to participate in water conservation programs, as those who already have an awareness around water and how they use it. The down side to this connection is that, compared to other water customers, many of these participants are already doing a relatively good job of conserving water. Water conservation programs that raise awareness don’t merely give people financial or technical assistance, but modify water-users’ understanding of how they might waste water. The reframing happens by showing users how waste can be eliminated without compromising their quality of life.

Respondents also reported that consumers often equate conservation with doing without or sacrificing. The connection between conservation and sacrifice has historic roots in Austin, and can be partly attributed to the development of water rationing programs after both the failure of the dam in 1900 and the infrastructure inadequacies of the 1980s. Numerous responses from those interviewed suggest that water conservation managers are still in a process of reframing customers’ perception of conservation. Most respondents’ asserted that they weren’t asking customers to sacrifice, but rather to reduce water use in ways that would not impact the customers’ quality of life. A primary way they ask customers to do this is to water their lawn efficiently, not to eliminate their lawn altogether.

For many water users, reframing water conservation as eliminating waste is difficult, partly because of what Yager describes as their adamant framing of water as a commodity that should be regulated by market demand and not policy. Water users with this perspective were described as less likely to want to participate out of a sense of duty to the environment or public good. Nate Booker claimed that financial incentives were the most important for many AWU customers. In contrast, many respondents agreed that programs must appeal to customers' pocketbooks and sense of environmental or public responsibility, although they did not all agree on the relative importance of these factors. Aukum mentioned that for many SAWS customers, the price of water is just too small compared to other living expenses to really register with customers. Instead of merely appealing to customers' pocketbooks, it was most important for SAWS programs to appeal to customers desire to do the right thing.

How Programs Work:

Conservation programs are often categorized by the target location of the solution, such as indoor or outdoor, but they also can be categorized based on the type of solution, such as efficient technology, or changing behaviors. Indoor and outdoor programs address different needs. Around half of residential water is used indoors. Indoor water conservation programs have the added benefit of reducing the amount of water that must be treated at a wastewater facility. Alex Yager suggests that if a homeowner replaces all indoor fixtures, that they can save five or six thousand gallons per year. These savings, Yager notes, are miniscule compared to the typical amount of water wasted outdoors.

Technologically oriented programs generally replace inefficient technologies with more water efficient technologies. Front-loading washing machines, low flow showerheads, faucet aerators, landscape rebates, and efficient toilets are examples of popular technologies used by water utility conservation programs to reduce water use. Each of these new technologies, as well as their manufactures and suppliers, become new actors within Austin's water network.

Programs that target customer behavior try to educate users about how they can change their water use habits in order to reduce their water consumption. General education around household water use, tiered water rates, water budgets, and to lesser degrees, irrigation audits and rain water collection are examples of programs used by water utility programs to reduce water use.

Respondents mentioned that conservation departments frequently relied more on non-behavioral strategies than behavioral strategies. One reason for this, which will be discussed further in *the metrics of conservation programs*, is reliability – or, as Nate Booker put it, "You don't have to remind an efficient toilet to flush 1.6 gallons."[123] However, not all technologies are equal in this respect. Technologies that replace a similar technology and require the same behavior, such as a new efficient toilet, may be very reliable. As the quantitative model findings in Chapter 8 will suggest, the reliability of these savings assumes that the new technology isn't defective or poorly designed. Irrigation systems, drought tolerant plants, and rainwater collection all are somewhat non-behavioral; however, they also create a new system with new rules, new actors, and new artifacts to be learned by users. If the users don't know the new rules and don't have established habits pertaining to the system, then these technological systems fail to produce water savings. With any of these systems, failure to utilize them correctly can either be very expensive, a waste of water, or both.

[123] Booker, Nate. Interview, (2009).

Technological and behavioral categories can be a convenient way of describing some programs, but many programs would be better described as a hybrid, a techno-social system. As I will discuss later in this chapter, the array of conservation programs offered by utilities also represent a social-techno development. The programs strategies used by utilities are influenced by informed assumptions made by key actors within the utility system. Often these informed assumptions produce different program incentives for technologically oriented programs than for behaviorally oriented programs.

Toilet Programs:

The toilet replacement programs are often adopted early at water conservation departments, and treated as a fundamentally important program for residential water conservation. They are generally regarded as being capable of great savings and easy to implement. The free toilet program allows Austin Water Utility customers to use a City voucher to pay for a toilet that is picked up at specific local plumbing shops. The toilet rebate program allows users to receive a rebate for designated toilets. According to Nate Booker, free toilet participants are generally less affluent, while those participating in the toilet rebate are generally more affluent. The rebate program typically has offered more choices in toilet design as well as options for ultra-efficient toilets.

Water utilities have greatly benefited from the existence of low-flow and efficient technologies. However, these programs represent low hanging fruit that will not be around forever. Some cities have replaced so many toilets that they are searching for the ones they haven't replaced yet.[124] There is a limit to how much water can be saved by replacing toilets. According to Nate Booker, the success of Austin's toilet programs, and ones like it around the country, have revolutionized the toilet manufacturing market.

Washing Machine Rebates:

Washing machine programs operate in a similar manner to the toilet rebate, with one exception – efficient washing machines are generally much more expensive than high efficiency toilets.[125] According to Nate Booker, this distinction made the program a niche incentive during its early years. Since the washer rebate program began, the number of washers on the market and number of less expensive washers has increased substantially. Now that the washer market has diversified, Booker believes that the pool of participants is much more economically diverse.

[124] Aukum, Jodi. Interview, (2009).

[125] A cost benefit comparison between for these programs will be presented in Chapter 8.

Irrigation Audits:

Irrigation audits allow customers to invite conservation auditors to their property to provide technical assistance and education about proper scheduling and maintenance of an irrigation system. Like toilet programs, they are also a mainstay program for many utilities – most of which target high water users. The AWU Conservation Division website states that users must use at least 25,000 gallons during summer months. However, a respondent familiar with the divisions procedures stated that, technically, it is open to anyone, although the auditors prioritize aiding customers that use more water. Multiple respondents mentioned that some customers over-water so much that they occasionally kill some of their plants. Respondents also overwhelmingly believed that this over-watering is due to customers' ignorance about the needs to assume that more water is better. Rebates for upgrades to an existing irrigation system are available, although I received little information about them.

Rain Barrels and Rain Water Harvesting:

Austin Water considers rain barrels to be educational and marketing tools, rather than a way of reducing water use through a distributed water supply system. From this perspective, the water savings do not come from the use of the barrel per se, but from the idea of conservation that the barrel promotes. The promotion of conservation values by these systems is believed to extend to the surrounding community when they are made publicly visible. No respondent stated that they have an idea how much water might actually be saved through this educational device. Respondents frequently stated that they perceive rain barrel programs as high cost with low savings. Utilities that promote rain barrels rationalize their cost by suggesting that the message they carry could be worth more than the gallons they directly save. The rain barrel program was supposed to be discontinued because of its perceived ineffectiveness, but it was kept because officials elsewhere in the City didn't want to let it go.

Rainwater harvesting systems, which must have a capacity of 300 gallons or more, are promoted as an supplement to the Utility's water. Like the rain barrels, the City only promotes these systems for outdoor non-potable uses, even though communities near Austin use these systems for all their household water needs as well. Respondents assumed that these systems might make some difference in water use, but that people who use them are already low water users, so the water savings potential may be smaller than with high water users that irrigate frequently. The City has asked all participants to make their site available for a tour to educate the community at large. The tours allow the program to extend the educational focus of the system beyond the household; although, according to Dominique Soloman, the City hasn't organized a tour in years.

People interested in rainwater harvesting systems are seen as the hard core contingent of rainwater collectors. According to Alex Yager, rainwater systems are most effective when they are integrated as a whole house system, that provides for multiple water needs within a household. However, Yager notes that despite some customer interest in such systems, Utilities find it difficult to rationalize subsidizing systems that may partially or completely eliminate their customer base using funds from other customers. According to Dominique Soloman, for many years the majority of applicants who requested a rebate for their rainwater harvesting system did so with help from a single private rainwater system installation company, who should be considered an important actor in the rainwater program's network.

Landscape Rebates:

The water wise landscape rebate program has deep roots in the Conservation Division. Xeriscaping was promoted early in the conservation department's history. Many respondents familiar with Austin's program recognize the strong relationship between lawns and water use. They even state that they would be very happy if people transitioned to less water intensive landscaping. However, most respondents stated that the landscape rebate programs don't easily produce water savings. Jodi Aukum stated that "you can rebate, use the right plants, right soil, right irrigation, and they will still over-water."[126] Additionally, Nate Booker and other respondents commented that most of the participants were low water users anyway – they either didn't have a lawn before, or didn't water. Many users actually used more water after participating in the program. Alex Yager noted that the only part of landscape rebates that is effective is removing turf. Booker commented that after the Utility overhauled the program to better incentivize water conservation, participants' interest declined significantly, purportedly because of the increased program restrictions.

Conservation Metrics:

According to Nillis, measuring conserved water, and knowing what determines success are important aspects of how water conservation programs are managed. Unlike for water consumption, there isn't a meter that measures water conservation. The relative ease and confidence associated with evaluating program effectiveness influences how programs are designed and implemented. Nillis, Yager, and Aukum all stated that replacing fixtures and appliances represents real savings that are easy to document. According to Aukum and others, the converse is true for behavioral based programs. Water utilities are not sure they can count on behavioral programs to conserve water because the

[126] Aukum, Jodi. Interview, (2009).

savings and effective lifespan are hard to document. Nate Booker stated that for these reasons Austin Water "shies away from" giving incentives for programs that try to modify behavior.[127] Respondents familiar with conservation program evaluation remarked on the difficulty of creating a trustworthy understanding of program success. Estimating conserved water was described as elusive, not a science, and less than perfect. It seems that the water conservation industry needs continued research to identify if, how, and to what degree behavioral programs can provide opportunities to save water.

There is an underlying assumption that toilet programs will be effective for their life. In order to quantify this, program administrators use the length of the manufacturers' warranty as a basis for predicted life of water savings. However, unlike the toilet programs, it is difficult for utilities to know how long they can assume an irrigation audit will be successful. Conservation departments generally consider irrigation audits to last for a maximum of 2 years, although this number may vary between utilities. Nillis acknowledged that the assumption that replacing fixtures is an automatic savings is problematic. Nillis cited the improper maintenance, or different habits around toilet use, such as flushing twice to clear the bowl, as reasons why automatic savings from technologies aren't completely reliable.

[127] Booker, Nate. Interview. 2009.

The complete support for programs that are easy to measure at the expense of behavioral programs is problematic. Yager noted that retrofitting every appliance and fixture in a house is a minor savings compared to the amount of water wasted outside. Outdoor oriented programs at Austin Water, like the irrigation audit, and landscape rebate programs, have important behavioral components that often aren't incentivized at all. Incentives for the behavioral aspects of an irrigation audit could simply be rewarding customers for reducing their water usage. Booker noted that one reason why it is difficult to reward participants in these programs for lowering their water usage is that calculating the savings would consume valuable employee time. An automated method for this evaluation was reported as difficult to add to the billing system. While Austin Water Utility is currently developing new billing software, features such as this were not part of the package bid on by software developers.

The Texas Water Development Board's suggested target consumption level of 140 gallons per capita per day (gpcd) was provided to give cities a reasonable benchmark for success. One hundred forty gpcd was chosen as a benchmark, according to Nillis, because this low level of consumption had already been attained by San Antonio and El Paso. Austin currently uses approximately 170 gpcd, while Aukum reports that San Antonio actually considers reaching 140 gpcd “a bad year for conservation.”[128]

Conservation as Commodity:

Conservation departments frequently are run directly within their respective water utility, as is the case in Austin. The at times different goals of these departments can create a conflict of interest. On the one hand, the utility relies on revenue from water sales to maintain and expand the system as well as provide transfers of revenue to city coffers.[129] On the other hand, the conservation department’s goal is to reduce the amount of water used by customers. This often can result in lower revenues for the utility. This internal conflict between utility and conservation department goals was noted frequently by respondents.

Respondents familiar with Austin Water cited many reasons for the Utility’s interest in conserving water, and they were almost entirely associated with

[128] Aukum, Jodi. Interview, (2009). Austin’s 170 gpcd is based on the TWDB suggested method for calculating gpcd. San Antonio includes more types of water consumption (such as industrial) in their calculation making their low water use all the more impressive.

[129] Utility contributions from both Austin Energy and Austin Water currently provide around 20% of Austin’s general revenue.

saving money. This suggests that the City itself frames water as a commodity more than a resource to protect. In fact, the only Utility that respondents identified as framing conservation as environmental stewardship, at least rhetorically, was the LCRA. Compared to other Central Texas utilities, the LCRA has a unique mission to both provide water as a regional utility and ensure that the water resources within the Colorado River basin will be available in the future. However, this exception does not mean that the LCRA does not frame water as a commodity. Even though the LCRA has continued developing its conservation programs, it has also substantially increased the size of its service area – perhaps more than other utilities in Central Texas.

According to respondents, the framing of water as a commodity has a history within most utilities. Although many respondents suggested that there isn't a conflict between water sales and conservation today, several respondents suggested that it was at least partially present. The continued presence of this conflict between water utilities sales (including AWU) and their conservation departments' savings was noted by respondents. Several respondents mentioned that internal pressure from financial departments were directed towards conservation departments for lowering utility water sales. As noted in Chapter 5, this dynamic was noted by conservation employees at AWU as early as 1984. Other respondents cited that this is not always the case, and suggest it has changed from the early years when conservation first began at AWU.

The Situated Value of Conservation:

The price paid by cities for water varies wildly across the country. While Austin pays less than $150 an acre-foot (af), others without adequate supply might pay much more. The failed LCRA San Antonio project would have cost an estimated $1,500/af if it had been completed, and Denver's next water supply could be as much as $20,000/af.[130] According to Aukum, there is a situated cost of water, and therefore a situated value for conserving it. Due to this Aukum suggests that municipalities can only conserve water as aggressively as San Antonio if two conditions are true: a) the city identifies a water supply shortage, and b) they have an increasing population.

While Central Texas has a rapidly expanding population, a recent report by the LCRA suggests that water demand won't meet water supply limits here until 2070. Respondents acknowledged that Austin Water does not have the water supply constraints of San Antonio. Water supply limitations, according to Yager, can take many forms and some urban areas may not fully recognize how close they are to their limit. This, Aukum stated, was the case with Atlanta, GA which was surprised by a severe drought in 2007. The panicked response to the drought caused reactionary legislation by the State to limit municipalities in Georgia from imposing water restrictions without State approval.

[130] Aukum, Jodi. Interview, (2009).

Water supply limits could appear suddenly as man-made droughts, where shortages are exacerbated by an unrecognized consumption-supply imbalance. They could also occur due to the combination of growth and water infrastructure inadequacies, as occurred in Austin's early years providing water. These stories received from interview respondents corroborate City rationale for creating conservation task forces. The task forces were assembled to research ways to maintain adequate water supplies and allow WTP 4 to be delayed.

According to Aukum, the San Antonio Water System (SAWS), perceives their water limitations as an inconvenience, not a problem, like the limitations present in many desert cities.[131] Despite the fact that their shortage is framed as an inconvenience the chief financial officer ran the numbers and concluded that conservation was simply the most affordable way to create supply. A new budgeting model was developed in which the financial department assumes the programs will be successful, and plans for water sales to flatten, instead of perpetually increase. Budgets are developed around this new growth-model and rates are adjusted to allow the utility to bring in required revenue. The Chief Financial Officer now adamantly supports the conservation department and requests that it remain well funded. San Antonio Council members now proudly state that they serve "twice as many people with the same amount of water."[132]

[131] In 1996 the City of San Antonio was required by a court order to maintain the water level of the Edwards Aquifer above a specified height or face potential court take over. Aukum. Interview, 2009.

[132] Aukum, Jodi. Interview, (2009).

Their conservation programs have been successful enough that projected reclaimed water sales had to be adjusted because the amount of waste-water effluent produced flat lined.

Aukum attributed part of San Antonio Water System's success to how they have shaped water conservation programs to reach out to community members in unique ways. The community outreach allowed conservation managers to overcome what they saw as the primary obstacle to customer participation – the department's inability to "get past the static of people's everyday lives."[133] According to Aukum, the busy lifestyle of most customers creates a static-like barrier that makes it difficult for them to prioritize water conservation. SAWS began using grassroots tactics to bring water conservation into people's everyday lives by giving incentives to community organizations to sign pre-qualified customers up with specific water conservation programs, such as toilet incentive programs. Friends, relatives, community members, and community leaders then became conduits for learning about conservation. Additionally prospective participants now had the extra bonus of knowing that their participation would benefit a community organization in addition to any other benefits associated with the program.

[133] Aukum. Interview, 2009.

Conclusions:

Interview respondents have provided insight into how conservation managers perceive programs work, how they are evaluated, and how conservation is valued. These findings add to a better understanding of institutions' water conservation goals and practices. Furthermore, the findings add to a more complete understanding of the actor-network responsible for water management in Austin.

Respondents describe decision-making around water conservation to include a variety of assumptions regarding how programs work and how they are evaluated. Table 6 describes how conservation experts frame target problems, the identified solution, and how program savings are calculated.

Table 6: Conservation Programs: Problems, Solutions, and Percieved Effectiveness.

	Free Toilet	Toilet Rebate	Washer	Irrigation Audit	Rain Barrel Sales	Rain Water Harvesting	Landscape Rebate
Water Problem	Technological efficiency	Technological efficiency	Technological efficiency	Technological & Educational efficiency	Educational Technology	Technological & Behavioral	Botanical efficiency, botanical knowledge
Program Solution	Replacing technology	Replacing technology	Replacing technology	modifying technology	Introducing technology	Introducing technology	Introducing new vegetation
Metrics: Percieved effectiveness	Assumed: Dependent on length of warranty - ten years.	Assumed: Dependent on length of warranty - ten years.	Assumed: Dependent on length of warranty.	Assumed: Tenatively two years of savings.	Assumed: based on 5 year 'contract' with participant.	Unknown.	Measured: savings by some are 'washed away' by excess use by others.

Table 6 shows that while programs that try to solve technological problems always use technological solutions, programs that try to solve technological/botanical and behavioral problems often do not receive an incentive to create shifts in behavior. This difference in framing the problem and framing the solution identifies specific programs that could benefit from a new framing of problem or solution. By reframing the problem and solution, new benefits can be made available to citizen-consumers which, Actor Network Theory holds, will providing reasons for them to join the water network.

The utility also approaches measuring the programs' success with different techniques for different programs. As will be discussed in Chapter 9, findings from the quantitative model suggest that creating better modes of evaluation for certain programs may provide a better understanding of savings. More accurate conservation metrics may provide good reasons for changing how conservation programs approach water-use problems.

While respondents show that conservation managers often frame problems and solutions as either technological or behavioral, there is almost always a behavioral or technological aspect to each problem and solution. Solving technological problems can be as simple as replacing an old technology with a 'new technology.' However, when the 'new technology' is very different from the previous technology, it present new opportunities in which new habits can, and should, be formed. In these circumstances, the approach to solving the problem will be most successful if new technological-knowledge and technological-habits are formed.

The situated cost of conservation, as framed by Aukum, provides an explanation for why conservation may be recognized as a less expensive alternative to producing water but still might not be pursued aggressively. In this alternate model for evaluating the value of water and water conservation, it is not current cost and current savings that are important, but current revenues compared to future costs. The cost benefit calculation for water conservation is not to conserve more water when the cost of current water production is greater than the savings per gallon. Rather, the situated cost of conserving means that it is only better to conserve more water when the revenue from current and near future sales is less than the savings afforded by delaying the future cost of water.

This situated model of conservation involves perceiving different future water costs and understanding when they will be incurred. Calculating the future cost of water can be very challenging. The historic-interpretive and interview research have shown that calculating the future cost of water includes understanding the future cost of supply, infrastructure needs and costs, energy costs, environmental regulation, the reliability of water production, and the financial impacts of conservation. Figure 9 shows how different ways of framing the value of conservation can produce significantly different results in the development of the actor-network.

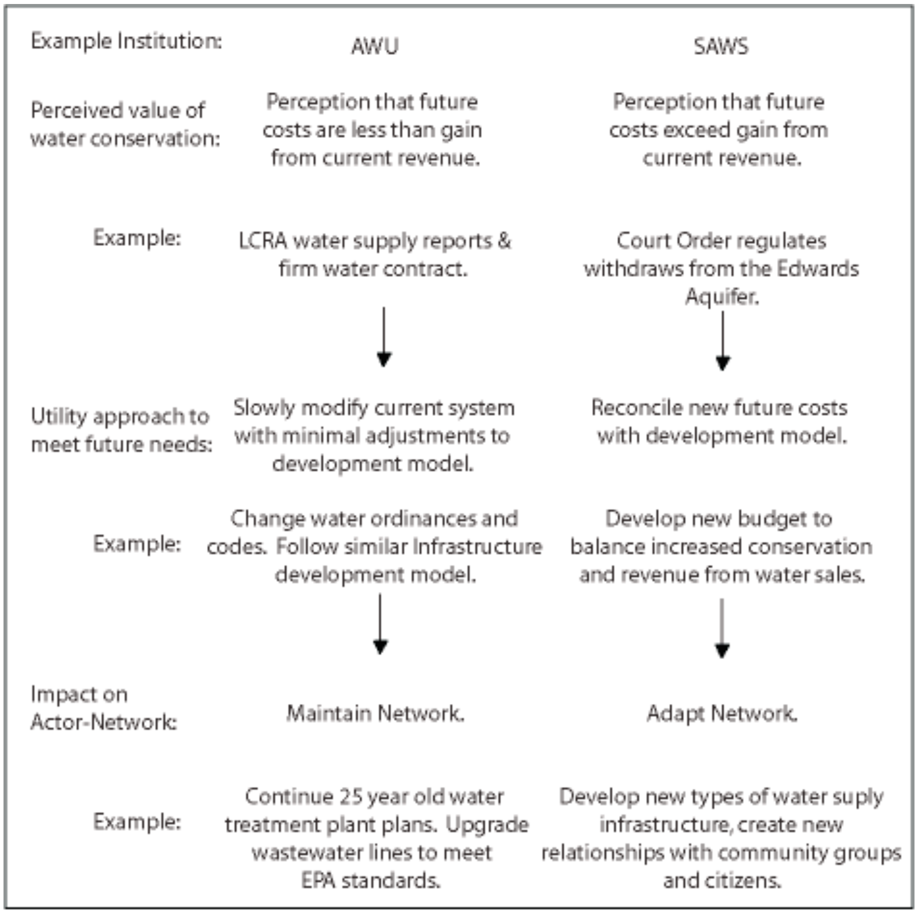


Figure 9: Situated Cost of Water Conservation and the Water Utility Actor-Network.

Findings from interview respondents show that small processes, such as evaluating conservation programs, and larger processes, such as framing the value of water, both have significant impacts on which actors, technologies, and behaviors are encouraged or discouraged from becoming part of the actor-network. The subsequent chapter will add to the understanding of this network by exploring water customers' behavior inside this network, what sorts of goals users have when they decide to conserve water, and how the programs empower different users to participate in this actor-network.

Chapter 7: Internet Survey Findings

Introduction:

In order to better understand local water users and participants in conservation programs, a sixteen-question Internet survey was conducted targeting local water consumers and potential participants in water conservation programs. One hundred and two Central Texas residents completed the survey. This survey adds to the citizen-consumer stories received in Chapter 6 from water professionals, and the 2004 Enviromedia *Texas Water Conservation Survey* that reached approximately 1,200 Texas residents.[134]

Survey questions and responses are listed on pages 125-130. This is followed by a general overview of key survey findings, and a summary of 'free responses.'[135] The next section details survey results relevant to several types of water conservation programs being studied, including: toilet programs, washer programs, irrigation audit programs, rain barrel programs, and landscape rebate programs. After evaluating the programs individually, I will conclude by first discussing how respondent attitudes to conservation, programs, and technology relate to the received stories about conservation programs at Austin Water,

[134] Baselice & Associates Inc, *Texas Water Conservation Survey* (2004).

[135] Survey Respondents were allowed to fill in their own responses for certain questions. These responses are called "free responses."

mentioned previously in Chapters 5 and 6. Second, I will present findings that show alternate ways to judge the success of citizen-consumers participation in conservation programs.

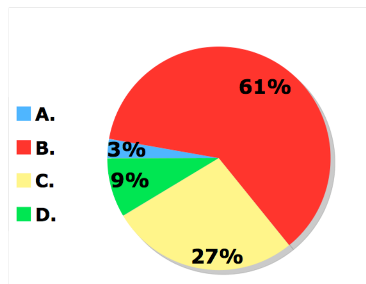
Internet Survey Questions and Responses:

Online Survey General Statistics

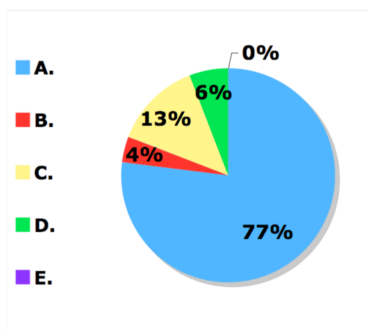
Viewed	120
Started	108
Completed	102
Completion Rate	94%
Drop Outs (After Starting)	6
Average number of minutes taken to complete the survey :	9

Survey Questions and Responses:

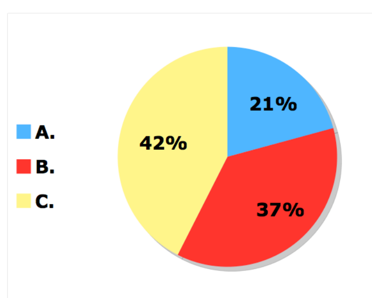
1.	Please describe your familiarity with water conservation programs:	Response (%)
A.	I know almost nothing about water conservation	3%
B.	I know a little about water conservation programs.	61%
C.	I know of most of the programs available to me.	27%
D.	I work in or study the field of water conservation.	9%



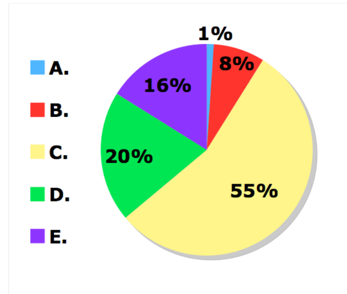
2.	Which option best describes why you would participate in a water conservation program:	Response (%)
A.	Conservation programs allow me to be a better steward of environmental resources.	77%
B.	Conservation programs allow my water utility to provide better and more affordable services.	4%
C.	Conservation programs help me reduce my bills.	13%
D.	Conservation programs let me save on improvements I would make anyway.	6%
E.	I would not participate in a water conservation program.	0%



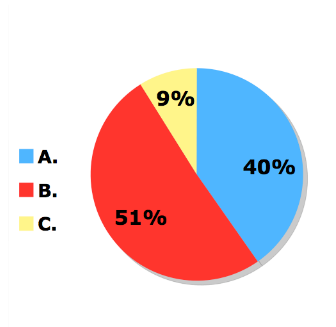
3.	Do you track your monthly water bill and usage?	Response (%)
A.	No, Almost never	21%
B.	Sometimes	37%
C.	Yes, Almost always	43%



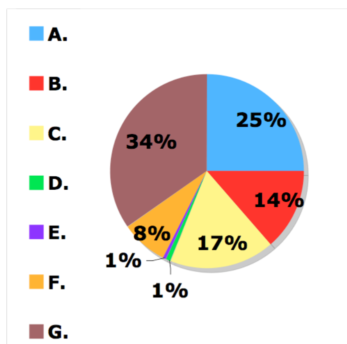
4.	How does the cost of your water bill effect how much water you use?	Response (%)
A.	I definitely use more water because it is	1%
B.	I probably use more water because it is inexpensive.	8%
C.	The cost of water does not effect how much I water I use.	55%
D.	I probably use less water because it is expensive.	20%
E.	I definitely use less water because it is expensive.	16%



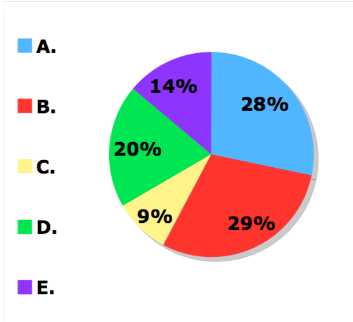
5.	Do you water a lawn or other outdoor landscaping?	Response (%)
A.	No.	40%
B.	Yes.	51%
C.	Yes, with an automatic irrigation system.	9%



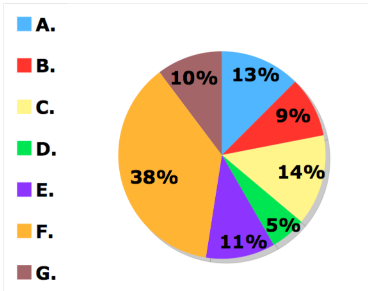
6.	Have you participated in any of the following types of programs through your water utility? Select all that apply:	Response (%)
A.	Received a discounted or free efficient toilet.	25%
B.	Received a discounted or free rainbarrel.	14%
C.	Received a discounted water efficient washing machine.	17%
D.	Received a discount to install a larger (300 gallons +) rainwater harvesting system.	1%
E.	Participated in an irrigation audit.	1%
F.	Received support to install vegetation with low water needs.	8%
G.	I havent done any of these.	35%



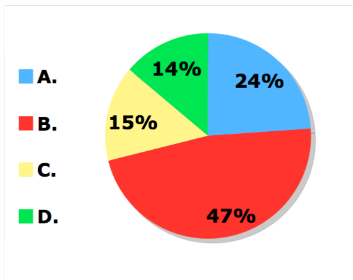
7.	If you participated in any of the previous programs, please mention why you participated. Please select all that apply.	Response (%)
A.	I didnt participate in any of the previously mentioned programs.	28%
B.	This/these programs allow me to be a better steward of environmental resources.	29%
C.	This/these programs allow my water utility to provide better and more affordable services.	9%
D.	This/these programs let me save on improvemets I would make anyway.	20%
E.	Other:	14%



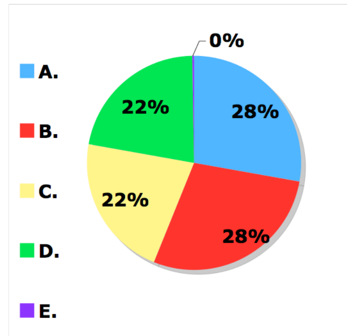
8.	Have you done any of the following without assistance from you water utility? Select all that apply:	Response (%)
A.	Replaced an inefficient toilet with an efficient toilet.	13%
B.	Installed a rainbarrel.	9%
C.	Purchased an efficient washing machine.	14%
D.	Installed a larger (300 gallons +) rainwater harvesting system.	5%
E.	Monitor irrigation system regularly.	11%
F.	Planted vegetation with low water needs.	37%
G.	I havent done any of these.	10%



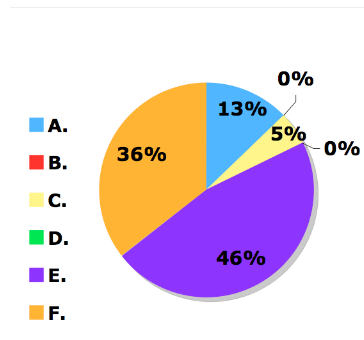
9.	What would be the best type of conservation program for your needs?	Response (%)
A.	Education about basic habits and conservation technology.	24%
B.	Rebates for efficient appliances and fixtures.	47%
C.	Incentives or requirements to water less outdoors (such as a mandatory watering schedule).	15%
D.	Other:	14%



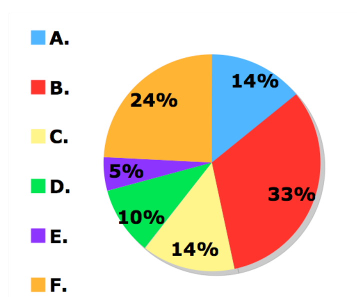
10.	Which of the following conservation measures would you support? Select all that apply.	Response (%)
A.	Incentives for water users to stay within a voluntary monthly water budget.	28%
B.	Water conservation efforts to increase the use of alternative systems such as reclaimed water or rainwater systems for new development.	28%
C.	Reduced rate loans for water conservation oriented home and landscape improvements.	22%
D.	Assistance for low income users.	22%
E.	None of the above.	0%



11.	What do you think is the largest barrier that limits your participation in water conservation programs?	Response (%)
A.	The cost of participating is too high compared to the savings.	13%
B.	I don't think water conservation is necessary.	0%
C.	Too much hassle to participate.	5%
D.	Im not interested in what the programs offer.	0%
E.	I don't have any barriers to participating.	46%
F.	Other:	36%

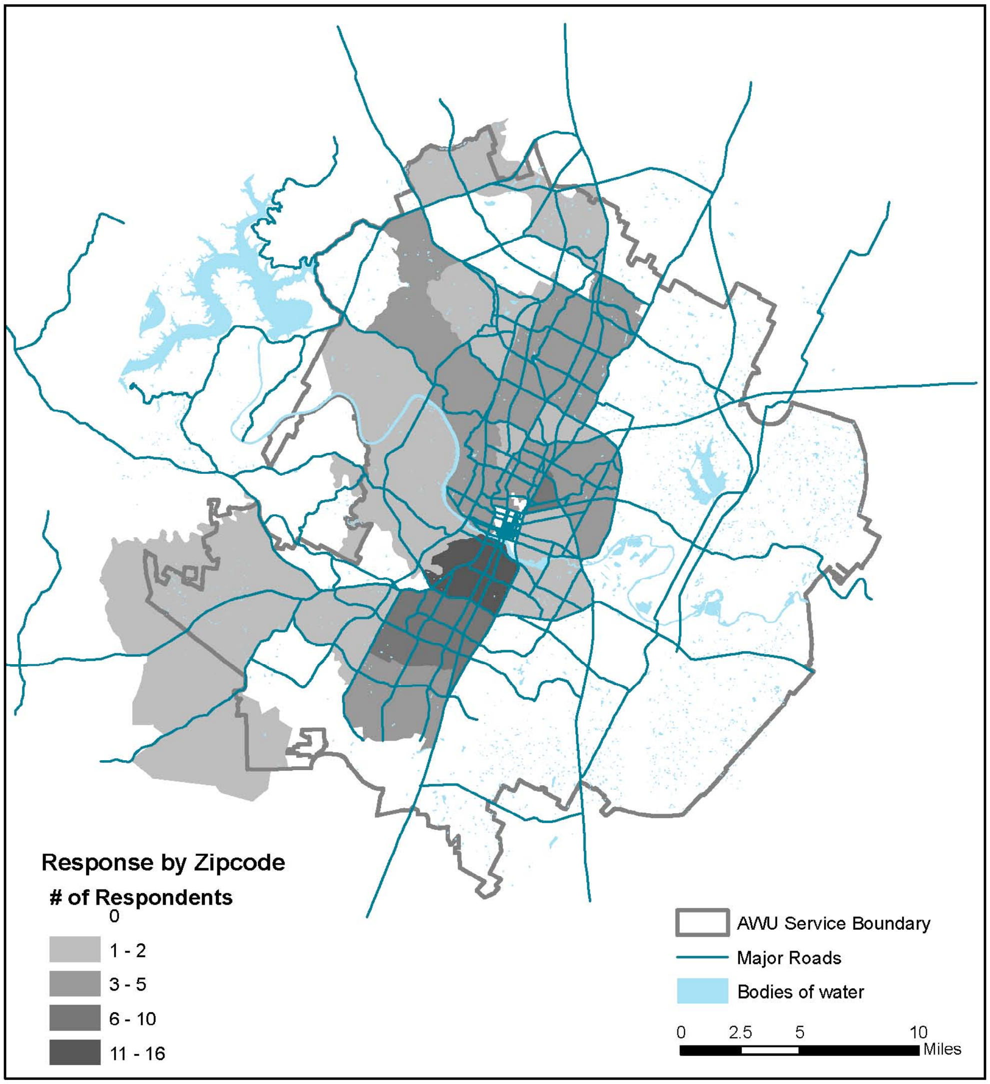


12.	What do you think is the largest barrier that limits other central Texas residents from participating in water conservation program?	Response (%)
A.	The cost of participating is too high compared to the savings	14%
B.	They dont think conservation is important.	33%
C.	The programs are too much of a hassle.	14%
D.	They are not interested in what the programs have to offer.	10%
E.	I dont believe the barriers to participating are significant for others.	5%
F.	Other:	24%



13.	It is useful to know some basic demographic information about people who respond to this survey. Would you share the following with me? What is your 5 digit zip code?	Response Mapped

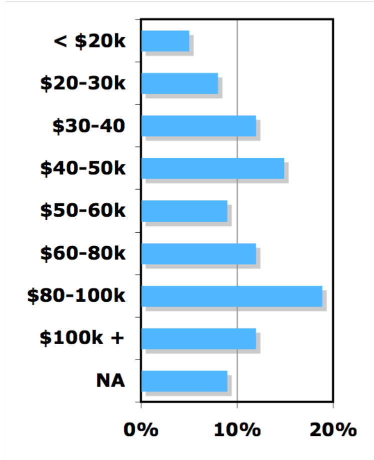
Citizen Response to Survey



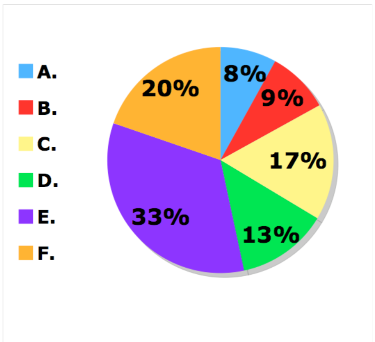
Produced by the Author
June 2009

This map shows the distribution survey respondents.
The survey was used to understand local citizen-customers perceptoin of, and activity in water conservation programs at the AustinWater Utility (AWU).

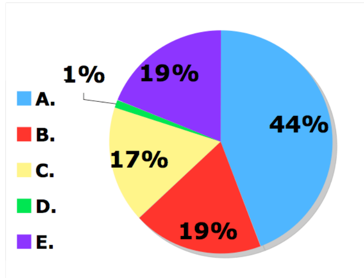
14. It is useful to know the general level of income for people responding to this survey. Could you select the response that closest matches your pre-tax income?	Response (%)
Under $20,000	5%
$20,000 but less than $30,000	8%
$30,000 but less than $40,000	12%
$40,000 but less than $50,000	15%
$50,000 but less than $60,000	9%
$60,000 but less than $80,000	12%
$80,000 but less than $100,000	19%
$100,000 & over	12%
I would rather not share this information.	9%



15. How long have you lived in the area?		Response (%)
A.	Less than 1 year	8%
B.	1-2 years	9%
C.	2-5 years	17%
D.	5-10 years	13%
E.	More than 10 years	33%
F.	For the most part I have always lived in central Texas.	20%



16. If you moved to central Texas from somewhere else, did you move from a drier or wetter place?		Response (%)
A.	Wetter.	44%
B.	About the same.	19%
C.	Drier.	17%
D.	I don't know.	1%
E.	Not applicable.	19%



Survey Overview:

Demographically, Internet survey respondents are somewhat wealthier than other Austin residents on average, more than 60% live in houses, and approximately half of respondents who moved to Austin in the last 5 years moved from a wetter environment. Responses to the survey came from all over Austin, except for east Austin, which hardly replied at all.

Sixty-five percent of respondents identify as knowing little to nothing of water conservation programs. Sixty-five percent of respondents also stated that they have participated in an utility sponsored water conservation program. Eighty percent would or do participate in water conservation programs in order to be an environmental steward, only 14% participate to save money. Incentives and rebates were reported as the most preferred type of conservation program.

Only a third of respondents reported that the cost of water reduces their water use, and 10% stated that the low cost of water increased how much water they use. The relatively low responsiveness to tiered water pricing suggests that it is only a mildly effective strategy – with half of the respondents replying that the cost of water does not effect their water use at all. As stories received from water conservation experts have stated, customers may not want to reduce their water use because they link water use to a quality of life that they enjoy and are willing to pay for.

Several users commented in free response sections that they wanted better codes to support the use of use of grey water systems. While grey water codes are regulated by the state and not the city, the city does not really support installation of grey water systems through educational programs, as they have done with rainwater collection. The myth that grey water is not allowed in the City was mentioned in several free responses as requests that the city needed to legalize the use of grey water.

The free response section also revealed a fair number of users who felt unempowered to take part in water conservation programs because they were renters.[136] The feedback suggests that they would like programs to be tailored for renters. For AWU, students or renters present a difficult technological and educational investment. Not only do they have limited ownership and control of their physical space, but they might also move out of Austin and take any increased water conservation education with them. From an economic perspective, there are externalized benefits that the utility cannot fully realize from certain relationships with this group. While the Utility has conservation programs that target Multi-Family dwellings, participation in these programs is often not possible for inhabitant that do not own their unit. A full list of Internet survey free responses is listed in the appendix.[137]

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[136] It is not known what percentage of these respondents live in 'single-family' homes that are more eligible for the types of programs analyzed in this study.

137 Any free responses identifying the respondent have been removed from the appendix.

Program Related Findings:

Of the 102 respondents that completed the Internet survey 65% have participated in a utility-sponsored water conservation program, and 90% have taken similar water conservation actions without assistance. About 8% haven't taken any of the listed water conservation actions with or without assistance. In this section I will provide a program by program overview of survey results.

Free Toilet and Toilet Rebate:

Just under half (44%) of toilet program participants stated that they did so to help the environment, while around a third (28%) stated they did so to help save on improvements that they were going to make anyway. Fifty-two percent of those who participated in a toilet program thought that rebates for appliances and fixtures would be the best type of conservation program for them. Nearly four times as many respondents that made fewer than $40,000/year stated they upgraded to an efficient toilet with assistance from a conservation program compared to those who did so without assistance. Two respondents commented in the free response's section that they experienced that the inefficient toilets did not work well for them, (see appendix question 7).

Washer:

Of those who participated in the washer program 40% did so for environmental reasons, and 43% did so to help save on improvements that they were going to make anyway. While nearly the same number of respondents replaced a washer with assistance from a program as those who did so without assistance, twice as many respondents who made less than $40,000/year installed an efficient washer with the help of a rebate program compared to those who did so without assistance.

Irrigation Audit:

Since only one person who took the survey participated in the irrigation audit, it is difficult to draw any conclusions. However, some conclusions can be drawn by analyzing responses from other questions. By looking at responses from those who use irrigation systems some details can surmised. Only 28% of respondents who use an irrigation system monitor it regularly. Those with an irrigation system were half as likely to install plants with lower water consumption needs as other respondents.

In question 9, respondents with irrigation systems equally preferred conservation programs targeting education about basic habits and technology rebates for efficient fixtures and appliances and incentives or requirements to water less outdoors. This is in stark contrast to those who water a lawn without an irrigation system, who by a factor of more than five to one preferred programs targeting general education and rebates over outdoor incentives or requirements.

In question 10, respondents' support of various types of conservation programs – such as voluntary water budgets, alternate water supplies for new development, reduced rate loans for conservation investments, and assistance for low income users – did not vary by outdoor watering habits. In essence, watering habits are not related to types of voluntary programs that respondents would support for all users, but these habits do seem to be sensitive to incentive or mandatory programs they would choose for themselves.

Rain barrel Sales:

Forty-four percent of those who participated in the City's rain barrel program and 71% of those who installed one on their own responded that they did so to be a better environmental steward. Nearly 30% of rain barrel participants also responded that they would participate in water conservation programs to help reduce their bills – nearly twice as much as other respondents. Rain barrel participants responded that they would participate in a conservation program to allow their water utility to provide better and more affordable services – nearly twice the support as participants from any other program. Comparable amounts of respondents who made less than $40,000 a year installed rain barrels regardless of whether or not they received it at a discount from the City.

Landscape Rebate:

When asked what type of program would be best for their needs, respondents who participated in the landscape rebate program responded positively in support for both rebates for efficient fixtures and appliances and for incentives or requirements to water less outdoors, but did not support education about basic habits and technology at all. This is interesting since stories received from experts familiar with Austin Water Utility's water wise landscape program stated that participants lacked an understanding of how much water their plants need. Landscape rebate participants supported incentives to remain within a water budget more than most other program participants.

Nearly seven times as many respondents planted vegetation with low water needs that did not receive assistance from the City as those who did and received assistance. While the actual income distribution of those who planted vegetation with low water needs was fairly similar for both groups, more people, regardless of income, would prefer to do so without being a participant. Those who participated in the landscape rebate program were generally more affluent, and those who installed low water use plants had varied levels of income.

Those who planted vegetation with low water needs, regardless of assistance, selected that their preferred type of program would be rebates for efficient appliances and fixtures. Those who participated in the landscape rebate program stated that their second preference would be incentives or requirements to water less outdoors (30%) and their least preferred option would be education about basic habits and conservation technology (0%). Conversely those who planted similar vegetation without assistance stated that they would prefer educational approaches (28%) to watering incentives or requirements (11%). Thirty percent of those who participated in the landscape rebate program stated that the best type of program for them would be incentives or requirements to water less outdoors, compared to only 15% for respondents as a whole. Incentives and requirements are two programmatic components that enabled SAWS to modify their landscape rebate program to become more effective.

Conclusions:

The findings from the internet survey provide a better understanding of how customers relate to conservation, the city's programs, and new water conservation technology. The internet survey suggests that water conservation program participants have different reasons for conserving than do institutional-providers. While findings from historical-interpretation, and interviews show that AWU tends to value water as a commodity, findings from historical-interpretation, interviews, and the internet survey suggest that water users and program participants value water conservation, more often than not, for environmental reasons. This inconsistency between public and institutional values shows one reason why Austin's water conservation network is not expanding like the water conservation network in San Antonio.

Attitude towards conservation:

Respondents tended to value conservation for environmental reasons, although financial reasons were frequently cited as well. The fact that people cite environmental stewardship as the reason to conserve water partly contradicts received stories from water professionals about why people participate in conservation programs. The value of environmental stewardship over water savings found in this survey more closely resembles how interview respondent

Jodi Aukum characterizes SAWS' water users' desire to conserve as a way to do the right thing.

Attitude towards programs:

Overall, respondents supported new forms of conservation programs. Respondents' level of income did not seem to effect their attitude towards supporting various types of water conservation programs. Support for the listed programs in questions 9 and 10 was fairly evenly distributed among all program types for all income brackets.

Survey results also suggest that respondents' preference for program types, such as educational or rebate, varied by their past participation experience. For example, those who participated in landscape rebate programs tended to prefer non-educational approaches to conservation. These incentives were chosen by a third of participants as their preferred type of incentive. Yet, stories received about this program suggest that Austin Water Utility believes that the program failed because participants did not know enough about the plants to realize that they didn't need heavy watering. Austin Water did not include incentives or requirements to water less outdoors as part of their landscape rebate program. SAWS, which has reported growing margins of success with their landscape rebate program, has moved to using these types of incentives.

Jodi Aukum indicated that SAWS' landscape rebate program is, although slowly, finally becoming successful at reducing water use.

Survey respondents also indicated that those who used an irrigation system were more inclined to prefer mandatory watering programs and incentives for users to stay within voluntary water budgets, than those without irrigation systems.

Attitude towards new technology:

Alternative water systems such as grey water are mentioned repeatedly in free responses as a type of water conservation the City could support, potentially by helping develop alternative technologies. The citizens' support for grey water from this study is complemented by results from the Enviromedia *Texas Water Conservation Survey*. The statewide findings of 100 water-use stakeholders, showed that 83% of stakeholders thought grey water is an effective way to conserve water. Comparatively only 63% of stakeholders in Texas think rainwater is an effective conservation measure.[138] One respondent to this Internet survey mentioned the need for new actors in the water service system. Grey-water and rainwater service industries were suggested to help maintain systems in order for these technologies to be viable. Stories received from

[138] Baselice & Associates Inc., 2004.

interview respondents, however, mentioned that utility support for these alternative types of water conservation systems is weak because they cannot properly value decentralized systems.

Residential Water-users and the Actor-Network:

Respondent openness towards new technologies, conservation, and types of programs suggest that they are willing, or want to be part of a more diverse actor-network. As new residents move to Austin, the actor-network is altered through changing demographic values of citizen-consumers, as well as the overall demand placed on the water service system.

Findings from interviews and the internet study provide conflicting perspectives of water users' habits and motives. While Booker claimed that the actors at AWU thought water customers tended to conserve water in order to save money, findings from the Internet survey suggest that water-users value conservation for environmental reasons highly. Furthermore survey findings show that less than half of respondents thought that water prices affected their water-use. Institutional perspectives of water-users identified at SAWS more closely resembles the findings from the survey. Aukum stated that conservation managers at SAWS understood that users had some financial motives. However, they also thought that it was important to create conservation programs and messages as a way of allowing the customer to do the right thing, in addition to any financial savings. Survey findings also indicate that certain programs have enticed water users to participate, instead of doing similar conservation actions without City support, more than other programs. The findings also show that certain programs have enticed water users who make less than $40,000/year to participate, instead of completing similar conservation actions without city support, more than other programs. These results, along with participants attitudes towards programs are shown in Table 7. The findings suggest alternate ways of understanding program success for water customers and participants. Program success can be defined not only as gallons saved, but by how well they serve those that need the resources most, and how well they fit customers preferred strategies for conservation.

These results indicate new understandings of the actor-network for water conservation. First, it appears that customers pursue conservation on their own, without utility support. Second, certain programs appear to provide significant aid to customers with low incomes. Third, participants' attitudes towards conservation program incentives vary. These findings suggest that the Water Utility's conservation programs may benefit from expanding their network to include new ways of framing problems and benefits, as well as actor-groups that engage water users. Further recommendations based on these findings will be presented in the conclusions.

Table7 : Survey Respondent Participation and Attitude towards Conservation Programs.

	All Surveyed	Toilet	Washer	Lawn Irrigation Systems	Rain Barrel	Water Efficient Landscape Improvement
Do more customers choose to participate or complete similar conservation measures on their own?	More customers have done similar actions on their own. 54% cited a barrier to participating in city programs.	50% more replaced toilets with city support than did so on their own.	Similar amounts, but 43% who participate are 'freeloaders' that would have made the improvements anyway.	Twenty times more do it on their own.	Similar amounts do the same on their own.	Seven times more did this on their own
Do Programs assit low income Customers?	Financial incentive such as rebates were liked by many respondents, but was also often listed as 2nd priority.	Four times more participate in this program who make less than $40,000/yr compared to those who do the same on their own.	Two times more participate in this program who make less than $40,000/yr compared to those who do the same on their own.	No respondents who participated in the irrigation audit had low incomes.	Similar amounts do the same on their own who make less than $40,000/yr.	50% more participate in this program who make less than $40,000/yr compared to those who do the same on their own.
Citizens attituted towards programs.	Considerable lack of awareness, Environmental motives. Customers interests are varied.	Prefer rebates for fixtures and appliances over other incentives.	Prefer rebates for fixtures and appliances over other incentives.	Those with irrigation systems were much more interested in voluntary water budgets than most other customers.	Larger interst in conservation to reduce utility bills and to help water utility provide better services than other customers.	Interested in rebates and outdoor watering incentives - less interested in education than other citizens.

Chapter 8: Quantitative Findings

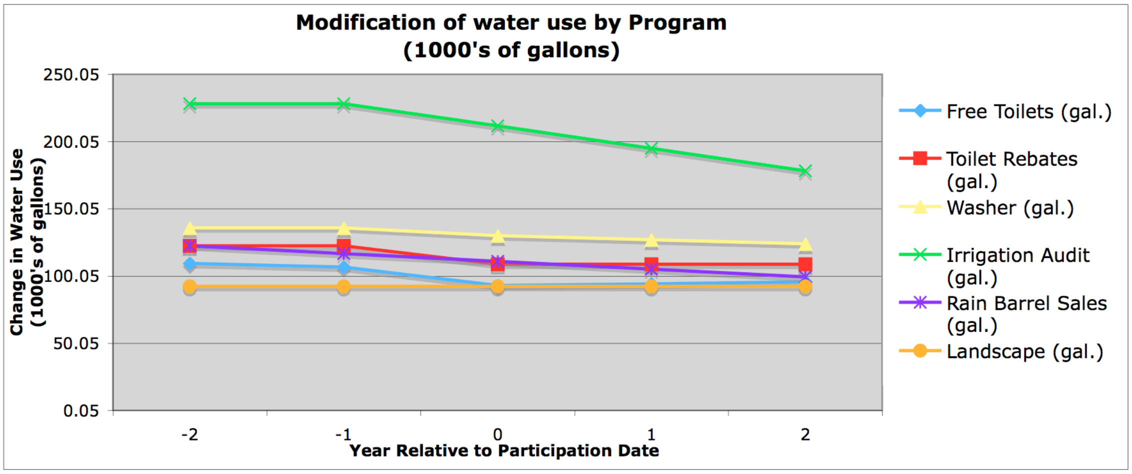
Introduction:

As explained in Chapter 2, the quantitative models examine the effectiveness of six conservation programs over a twelve-year period between 1995 and 2006. The model was developed to assess the impacts of the conservation programs on water consumption. Understanding the success of the programs helps verify the validity of my hypothesis – that water conservation programs will be successful if both institutional-producer goals and citizen-consumer goals are both satisfied.

The results show a varying degree of success within the programs. While some are successful at saving water, others don't significantly change the water use of participants at all. Figure 10, *Modification of water use by Program*, compares all of the programs' savings. This chart provides the best available graphical interpretation of the results over five-year study period.[139] To expand upon this somewhat problematic representation of the models results, I will also analyze the raw results for each program.

[139] Since all of the results required for an accurate five-year graphical representation were not significant, this graph does not represent a complete understanding of how programs affect water use.

Figure 10: Modification of Water Use by Program.



The preceding charts show that all programs except the landscape rebate program reduced water consumption. Furthermore, the irrigation audit and rain barrel sales programs appear to be the most successful over the entire five-year period. All of the programs, except for the landscape rebate program, show success during the initial year of participation. The individual significant results from the model led to a different understanding of the results. Table 8 shows the model results for both all water users and participants in each program.[140]

Table 8 is more detailed than chart above because it specifically lists which results were significant and which were not. Additionally, it lists covariate effects on water consumption for all users and for each program. [141] Before

[140] All water users represent approximately 41,000 water users. Some of these users have participated in various water conservation programs, while nearly half have not.

[141] Results with a p value less than .05 are considered significant. The least significant result used in this study has a p value of .029. See the appendix for all model results, including specific

interpreting the results, I will first describe the variables within the *general program information*, *overall consumption patterns*, and *covariates effect on water consumption* categories. Then I will continue to interpret the result for each program.

p values for each program. Graphs of covariate effects on water consumption are available in the Appendix

Table 8: Quantitative Model Results.

	All Users	Free Toilet	Toilet Rebate	Washer	Irrigation Audit	Rain Barrel	Landscape Rebate
General Program Information							
Household Size (people)	2.7	2.8	2.5	2.4	2.6	2.6	2.6
House Size (1,000 ft2)	2.5	2.3	2.6	2.6	3.0	2.5	2.6
Lot Size (1,000 ft2)	10.5	9.2	14.3	10.9	14.0	10.8	11.4
Instances of Participation	NA	1.8	1.2	1.1	1.1	1.6	1.0
Total Number of Participants Studied (in thousands)	41.6	21.8	7.5	8.7	1.3	2.0	0.2
Overall Consumption patterns							
Mean Use (at year of participation)	**114**	**104**	**122**	**135**	**228**	**111**	**92**
Change in use as a general trend for participants (yearly for all 5 years)	**-3**	**-3**	-	-	-	**-6**	-
Change in use during participation (1 year)	NA	**-5**	**-6**	**-6**	**-16**	-	-
Change in use after participation (yearly for last 2 years)	NA	**2**	-	-3	-17	-	-
Covariates Effect on Water Consumption							
Change in use per person in household	**6**	**4**	-	8	-	-	-
Change in use per 1000 ft^2 of house	**30**	**14**	**30**	**33**	**29**	**29**	-
Change in use per 5000 ft^2 of Lot	**11**	4	**9**	**15**	**22**	7	-
Change in use per inch of rain per month (May-Sept. only)	**-10**	**-6**	**-11**	**-10**	**-19**	**-12**	-

All Consumption numbers represent use in thousands of gallons.
Dashes indicate results were not significant.
NA: Participation results don't apply for "all users".
Bolded numbers represent p values < .0005.

General Program Information:

The general program information describes the raw data before it was processed in the model. These descriptors provide demographic information about the users and participants as well as the general quantity of data points analyzed.

The first three descriptors show average size information related to the study – *household size, house size,* and *lot size*. The covariates show how key factors, other than participation, effect water consumption. Instances of participation show the mean number of times that a residence participated in a program. This helps predict the mean household savings that can be attributed to a program. Covariate values show how much water use would change as a deviation from the average unit value for each program, or all users. The change in use per person in a household for all users is 6,000 gallons/year - for every additional inhabitant above the average number of 2.7 inhabitants. This also can be interpreted for smaller than average covariate values. For smaller than average values, the model predicts that a smaller household would decrease its usage by 6,000 gallons/year per fewer inhabitant.

Mean Use:

The first variable describing overall consumption patterns is the mean water usage for all water users or program participants during the year of participation.[142] In Table 8, the difference in mean values shows how users and participants have different water-consumption habits. Comparing participants' mean use to the all users mean use shows how program participants' water usage compares to the Austin water users in general.

Change in Use as a General Trend for Participants (yearly for all 5 years):

[142] More precisely, mean use is the average use of all participants, (or all users) at the year of participation (or the year 2001 for all users), where all independent variables are zero.

The second variable for overall consumption patterns represents the general trend for water use over the five year study. This number shows the general trend of water consumption over the entire five-year study period. For all users this indicator represents the trend over the entire 12 year study period.

Change in Use During Year of Participation (over one year):

The third variable for overall consumption patterns describes if and by how much water-use changed during the year of participation (for each instance of participation). For a household that received two new free toilets their water use would decrease by 5,000 gallons during this year for each toilet, Table 8.. Results are not available for all users for this variable since they are not associated with a program.

Change in Use After Participation (yearly for last 2 years):

The fourth variable for overall consumption patterns describes the trend in water for the two years after the year of participation. Like the previous variable this one is relative to the number of times participated. This shows that the amount of water used by participants in the free toilet program actually begins to creep back up after the year of participation. Results are not available for all users for this variable since they are not associated with a program.

Change in Use per Person in Household:

The first covariate describes how household size affects each program. For every additional person in a household with a free toilet, water use goes up by 4,000 gallons per year. The average household size for all users is 2.7 people.

Change in Use per 1,000 ft^2 of House:

The second covariate describes how the size of the participant's house is related to water consumption. The model predicts that both all users and washer program participants water-use will increase by 33,000 per gallons per year, per 1,000 ft^2 of house above the average size house size for these users.

Change in Use per 5,000 ft^2 of Lot:

The third covariate describes how a lot, or individual parcel of land, is related to water use. For every 5,000 ft^2 of lot above 14,000 ft^2 irrigation audit participants increased their water consumption by 22,000 gallons a year.

Change in Use per Inch of Rain per Month (May – September only):

The fourth covariate describes how rainfall during summer months effects water use. The model predicts that overall water use will decrease during summer months with rain. Water use for those who participate in the free toilet program decreases by half as much as participants in the rain barrel sales program.[143] Table 5, shows the monthly average rainfall used for this study.

Table 9: Rainfall in Austin (May-September), 1980-2006.

	Rainfall		
Year	May-September	Monthly Average	Deviation from average
1995	21.3	4.3	74.4
1996	19.3	3.9	82.1
1997	22.2	4.4	71.2
1998	11.3	2.3	139.6
1999	15.9	3.2	99.8
2000	12.6	2.5	125.4
2001	15.7	3.1	101.0
2002	17.4	3.5	91.0
2003	12.4	2.5	128.0
2004	19.1	3.8	83.0
2005	10.7	2.1	148.6
2006	12.2	2.4	130.1
average:	15.8	3.2	

Source: NOAA (As Recorded at Camp Mabry).

[143] The results from the model predict yearly reduction in water consumption, not monthly reduction. However the unit of measurement is mean monthly rainfall for an entire summer. While the summer is more technically June through September, a five month schedule was adopted to match the city of Austin's summer watering ordinance. Using average monthly units has the same effect as having one rainfall number for the entire year – the number in Table 8 refers to this average summer rainfall.

Interpretation of Model Results by Program:

In this interpretation of the model results, I will analyze each variable, and discuss whether the results corroborate stories received about the programs or suggest alternative findings. Afterwards, I will evaluate the success of each program. In Chapter 9, this evaluation will be used to determine the validity of the hypothesis.

Free Toilet program:

Participants in the free toilet program have the second lowest average water use compared with participants in other water conservation programs, at 104,000 gallons a year or approximately 8,600 gallons a month. These results predict that a household of 2.8 people participating in this program would use around 102 gallons per capita (inhabitant) per day (gpcd). The results from this program were the most significant of any program evaluated in this study, since every variable processed was significant.

The general water use trend for free toilet participants is a 2,700 gallon reduction each year. This is about the same as the yearly trend for all users, and half as large of a reduction as found for rain barrel participants. The similarity between free toilets and all users can be partly explained by the fact that new toilets have been regulated to be efficient, and so almost everyone is receiving efficient toilet replacements, regardless of their participation in this program. It can also be partly explained by the model and data. Data for free toilet participants represents nearly half of the data set for all water users.

The change in water use during the year of participation predicts that water use decreases about 5,000 gallons per toilet per year for free toilet participants. Such savings are entirely possible if the average participating household (2.8 people) replaced the average number of toilets (1.8) that each used 1.7 fewer gallons per flush (gpf), and each inhabitant flushed the average of 5 times a day.[144] Since many efficient toilets use 1.6 gpf, and many older models use 3.5 gpf, a reduction of 1.7 gallons is possible.

After initially participating, the trend for water use is a 2,000 gallons per toilet, per year increase. However, this can be partly explained by claims from some water users and water professionals that the efficient toilets aren't very efficient. Increased water use could be explained by poorly designed, or poorly maintained toilets. Poor design or lack of maintenance, which shouldn't be required for a two year old toilet, could result in poorly performing toilets that leak or require multiple flushes to clear the bowl of solid waste.

Relative to changes in house size, lot size, or rainfall, participants in the free toilet program have water consumption rates that fluctuate at half the rate of

[144] The AWWA Residential End Use Study states that the on average each person in a residential household flushes 5.05 times a day. (2.8 x 7.6 x 365 x 1.7 = 5000 x 1.8)

other participants. This indicates that their water use patterns are fairly stable. From these findings it seems that having a larger house does not change how they use their fixtures, nor does a larger lot affect their outdoor watering habits much. The relatively small decrease in water use with increased rainfall supports the idea that participants are not using very much water outdoors – or that they like to water just as much outside when it is raining as when it is not.

In many ways the results from the model support the stories about the free toilet program and its participants' water use patterns. According to the received stories from Chapter 6, free toilet recipients are less affluent. This would indicate that they would be less likely to have an irrigation system and that they would be the most sensitive to the tiered rate structure of the water bill. The sensitivity to utility costs may reinforce incentives to practice water conservation behavior.

Toilet Rebate:

The average initial water use of participants in the toilet rebate program is notably higher (17%) than for participants in the free toilet program. This difference cannot be ascribed to larger *household size*, since the average size is smaller than that of free toilet participants. The larger initial water use can be partly explained by the story received that toilet rebate participants are more affluent than those receiving free toilets, and either are more likely to have outdoor irrigation, or be less affected by the tiered water rates – or both.

While neither the before nor after participation water use trends were significant, the *change in water use during participation* was significant. At a 6,000 gallon reduction in water use, it is 20% more effective than the free toilet program. This increased effectiveness might possibly be due to the higher quality and more efficient toilets that are eligible through rebates.

The *change in water use by house size* for toilet rebate participants is similar to the same change for all other program participants, except for the free toilet program. The relatively typical *change in water use by lot size* suggests that even though toilet rebate participants have the largest lots on average, toilet rebate participants are relatively normal in the amount of water they use outside, compared with other program participants. The *change in use per inch of rain per month*, which is nearly identical to that of all users, confirms their rather typical outdoor water use. That the toilet rebate program covariates are more closely related to other programs other than the free toilet program is best explained by the relative outlier results of the free toilet program. Compared with other programs, the free toilet program simply is in a league of its own in terms of its water use patterns and demographics. The toilet rebate program demographic is closer to the demographic of other programs analyzed. The relatively conservative water use results shown by the lot size and rainfall covariates shows that, compared to the other programs, toilet rebate users, while affluent, do not have water use habits that tend to be as consumptive as those in the washer and irrigation audit programs.

Washing Machine Rebate:

The washing machine rebate participants' water usage is the second highest in the study. It also has a house size to house size ratio 25% greater than those participating in the free toilet program.

While there is no significant water use trend before participation, it is clear that participants in this program reduce their water usage significantly when participating, and somehow continue to reduce their water use even further after participating. The reduction in water use seems high, yet plausible.[145] The high amount of water saved could indicate that those participating in the washer program do other things to reduce their water use as well. The continued increase in water savings suggests that those participating in the washer program were pre-disposed to water conservation – or perhaps that the washer program acts as an intervention that inspires the inhabitants to reduce their water use in other ways.

The change in use per person covariate shows that participants in the washer rebate program tend to use more water per inhabitant than users at large, with a usage factor twice as high as those who participated in the free toilet

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[145] Efficient washers can easily save 15 gallons per load over conventional washers. Using data from the AWWA residential end use study, a typical savings of 4,320 gallons per year could be expected from those who participated. Even larger savings could result from more efficient washers.

program. Washer participants' water use also tends to fluctuate considerably with the size of their lot. This suggests they use a lot of water outdoors.

The washer rebate and toilet rebate produce similar savings during the year of participation. While the rebate for the washer program presents an equal or lower cost to the utility, the savings for participants in either program are about the same – around $100. Therefore, for customers wanting to save the most money by upgrading an indoor fixture or appliance, the toilet rebate program is probably one of the better purchases. This assumes that all else is equal, and, of course, this is not the case. The efficient washing machines are often appreciated because of detergent savings, energy savings, and floor space savings (for front load models stacked with a clothes drier).

Irrigation Audit:

Participants in the irrigation audit program have higher initial water usage than any other studied group. They also have a 15% larger house size per inhabitant than the average across the study, and the second (almost a tie for first) largest average lot size. These descriptors indicate that the group is somewhat more affluent than other participants.

While the change in use before participation did not result in a significant trend, the year of participation and post participation trend are the highest within the study at around 16,000 gallons a year. While these results are staggering, it is possible to achieve these savings because of the high initial consumption of water. It would take nearly 6 years of these constant reductions in water use for participants in this program to match the second highest water use group at 135,000 gallons per year.

While the relative change in water use, compared to house size, is average, the change per lot size and per rainfall is the highest of the study. The significant results from three of the covariates suggest that this abnormally high use of water is due mostly to outdoor irrigation. These results confirm received stories that it is difficult for water customers to use water in excess of 20,000 gallons a month without an outdoor irrigation system – or a very large leak.

The rather average household size could indicate that the high water use is not due to indoor water use needs. While the relative water use to number of inhabitants covariate returned insignificant, this insignificance suggests that the amount of water used by a household has little to do with its size, and has more to do with outdoor watering habits.[146]

These results confirm views that the irrigation audit participants use a lot of water and can, with the help of the audit intervention, reduce water use in large quantities. While the results do not show that water use declines for more

[146] Insignificant results do not 'prove' that there is not relationship, but rather prove that one was not found within the data and model used. Interpreting insignificant results as 'no clear relationship' is meaningful, although not conclusive or definite.

than two years after the initial year of participation, it does address the question of how long water conservation managers can expect the irrigation audit intervention to last. While two years is the longest that stories received suggested water conservation departments are willing to assume the program carries an effect, the large water savings predicted in post participation years by this study suggest that it is very possible that results could very well extend further than two years after an audit. By altering the model used to compute these results, it may be possible to obtain a better prediction of how long an irrigation audit remains effective.

Rain Barrel Sales:

The rain barrel sales participants are rather average in terms of house, lot, and household size, although rain barrel sales participants have the second highest participation rate within the study.

While their initial water use is the third lowest in the study, rain barrel participants have the greatest general water decrease of the entire study. This trend alone predicts that participants in the study become one of the lowest water users of the entire study by the end of the five-year study period, (see chart Figure 7, page 135). These findings are a little difficult to explain with the results from this model. The actual water savings from using the average 1.6 rain barrels to supplement one's water supply simply cannot produce this water use trend. Received stories from interview respondents suggested the rain barrels are not capable of saving very much water directly. This suggests that this group is reducing their water use in other ways. Some respondents stated that the rain barrels potentially act as an indirect supporter of the concept of conservation. These findings could support this belief, but probably are not conclusive. Since it is the general water use trend predicts this reduction and not the year of participation or post participation results, then the results mostly likely indicate that rain barrel participants are simply pre-disposed to conserving water. The rain barrels may not be responsible for reducing water use significantly, but, instead, rain barrels may simply be used by individuals that continually try to save water through other means.

The *water use relative to lot size* result is lower than most other programs evaluated. This suggests that those with rain barrels do not water extensively or excessively if they have a large lot. The relatively typical result for rain barrel participants *change in use per inch of rain per month* suggests that these participants react to rainfall about the same as all users. This indicates that the rainfall, which should theoretically fill their rain barrel, is not modifying their water consumption.

Landscape Rebate:

While the landscape rebate program results returned almost entirely insignificant, they are included in this study to allow a better discussion of the program in respect to the thesis results as a whole. The model predicts that landscape rebate participants have the lowest initial water use compared to any other program. There could be several reasons for the large number of insignificant results. First it could be due to a lack of data. This study only evaluates 210 instances of participation. This number of participants should technically be enough to return significant results; so, I will dismiss this theory with the assumption that these 210 participants are representative of the program as a whole.

Second, it could be because there is not a relationship between participating in this program and using less water. This interpretation is most similar to the story I received through interviews. The received stories suggest that water users don't change their behavior after participating, and that some participants even increase their water use, and wash out any savings gained from those who reduce their water use. If this interpretation is correct, then the results can be partly explained by the existence of at least two contrasting responses to the landscape rebate program. While some participants decrease their water-use, others increase their water-use. These diametrically opposed responses in water use create results that the quantitative model cannot interpret as significant.

Determining Program Success:

The quantitative model results are used in this section to determine program success, which is defined in Chapter 1 as the reduction in water use attributed to participation in one of the studied water conservation programs. In order of largest reduction of water to smallest, the following programs are clearly shown to be successful: Irrigation Audit, Washer, Toilet Rebate, and Free Toilet. While the rain barrel program does show participants' water consumption decreasing over time, this is only shown as a general trend that in part existed before the customer participated. Since the model results do not clearly show that the reason for reduction was participation in their rain barrel program, this trend could be explained by the users' predisposition to conserving water. For the rain barrel program and landscape rebate program the success is unknown.[147] In the next chapter I will examine the hypothesis to see if there is a correlation between each program's ability to satisfy participant and institutional goals and its success.

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[147]. Since the rain barrel results for the year of participation and years after participation came back insignificant, the results don't technically 'prove' it is unsuccessful.

Conclusions:

The results from the quantitative model suggest that received stories about the success of these programs are partly correct. The results add to these stories by suggesting that: a) the quality of the toilet used is very important; b) washer and toilet programs are of near equal success; and c) irrigation audits do appear to be very successful and have longer impacts than previously assumed.[148] These findings suggest that institutional choice of technology is very important. The findings that the irrigation audit is successful for at least two years after participation could potentially change the assumptions program coordinators make regarding the savings from irrigation audits. At the same time, the success of the irrigation audit suggests that programs that target behavior around water use and technology should be explored further.

[148] Future studies should be conducted to determine how far in the future results can be predicted.

Chapter 9: Analysis and Conclusions

Introduction:

Chapters five through eight presented findings from both qualitative and quantitative methods to provide a better understanding of what makes conservation programs successful, and to help determine the validity of the hypothesis – that programs will be successful if both institutional-producer and citizen-consumer goals are satisfied. Findings have shown that the proposed hypothesis explores a limited range of the actor network – the relationship between citizen-consumers and institutional-producers. The research results show that not only are more actors participating in the water and conservation actor-network, but that key decision making processes also help determine the limits of program success. The water actor-network includes advocacy organizations, politicians, engineers, and manufacturers of residential water technologies such as fixtures, appliances, and rain barrels.

The study's findings show that the institutional-producer goals for water conservation programs are focused on operating their services to meet customer and regulatory expectations. It is also clear that present institutional goals are oriented at delaying the need for new infrastructure and reducing future water cost increases related to Austin's agreement with the LCRA. On the other hand, Citizen-consumer goals have been oriented towards environmental agendas, reducing their cost of service, and attempts to control urban growth

In the following analysis and conclusions I will evaluate the hypothesis to test is validity. Since the findings also contained useful information about the larger actor-network, I will also discuss some key concepts within this larger actor-network and present a revised model to illustrate its relationships. To conclude I will use insights from the findings and analysis to provide recommendations that modify the actor-network so that it may achieve greater success at conserving water.

Evaluating the Hypothesis:

Findings have identified Water Utility and water customers' goals for water conservation. These findings have been interpreted and presented in Table 10, below, followed by an explanation of how I arrived at these conclusions.

Table 10: Hypothesis Evaluation Summary.

	Successful at reducing water:	Satisfied Participant Goals	Satisfied Institution Goals	Findings Support Hypothesis:
Free Toilet	Partly	Partly	Yes	Yes
Toilet Rebate	Yes	Yes	Yes	Yes
Washer	Yes	Yes	Yes	Yes
Irrigatoin Audit	Yes	Yes	Yes	Yes
Rain barrel Sales	Inconclusive	Inconclusive	Inconclusive	Inconclusive
Landscape Rebate	Inconclusive	Partly	No	Partly

The quantitative results for the toilet programs, washing machine rebate, and irrigation audit all suggest that the programs were mostly successful. Interviews suggest that most conservation divisions rely on these programs heavily to reduce residential water consumption and are satisfied with how they perform. Based on these programs' success, I will assume that the Utility is satisfied with them.

Users cited that they would participate in conservation programs to be a better environmental steward, to help make changes they would have done anyway. I believe that to the degree that water is saved they are much better stewards by using less of it. Users also stated that some of the programs would help them make upgrades they wanted to make anyway. In this situation the program should be successful as long as it does not limit their decision to choose a product that performs below their standards.

Toilet Programs:

While some respondents criticized some early efficient toilet designs, this should have been mostly corrected with the introduction of toilet performance testing in 2003. Since the quantitative model only covered participants whose actual year of participation was between 1997 and 2004, the impact from the

2003 Gauley Toilet performance standards would not have been relevant to evaluating or interpreting results from the quantitative model. The quantitative results suggest that the free toilet program actually lost effectiveness after participation, leading me to designate the program as only partly successful. I will argue that to the degree that the free toilets weren't successful at reducing water, participants weren't satisfied with their performance. This supports my hypothesis that there is a direct relationship between success and satisfaction of goals.

The toilet rebate was much more successful than the free toilet program at reducing water use. The quantitative results suggest that the rebated toilets were very effective. For this reason I will argue that the users should be satisfied with this program.

Washing Machine Rebate:

The number one reason washer program participants stated they wanted to participate was to save on improvements they would make anyway (43%). I'm assuming that participants were happy with their washers since I received no negative feedback about the washers. After the number of models on the market increased and the price range diversified, I would expect there to be few ways to be unsatisfied with this program. The Internet survey suggests another reason to consider this program successful. There is a greater diversity of incomes among those who participated. Nearly twice as many respondents who made fewer than $40,000 participated in the program, compared to those who bought a washer without assistance. Thus, these findings suggest that this program can increase equity and options for less affluent citizen-consumers to have assistance lowering their water usage. Since the washer program was very successful at reducing water use, I will conclude that the institution should be satisfied with the program.

Irrigation Audit:

While only one respondent from the Internet survey participated in an irrigation audit, other indicators suggest that customers are satisfied with it. Stories received from respondents suggest that participants in the program are mostly interested in lowering their water bill. The reduction in water use suggests that these participants and the Utility should be satisfied with the program.

Rain Barrel Sales:

The success of the rain barrel program is inconclusive. This is partly due to the overwhelmingly insignificant results from the quantitative model. Since it is unclear how successful the rain barrel is at promoting conservation, it is difficult to know if the program satisfies the institutional goal. This program does not support or refute the hypothesis. However, I am inclined to interpret the quantitative results as indicating that they don't save water. Furthermore, the quantitative study was not designed for evaluating a programs' ability to effect community consciousness around water conservation. It is difficult to know how well the program satisfies the Utility's goals because community water conservation was not measured,. For these reasons the results for the rain barrel program are inconclusive.

Landscape rebate:

While the insignificant results for the landscape rebate program show its' success is inconclusive, I believe the received stories about the program indicate it deserves a more nuanced interpretation. Insignificant results from the quantitative model show that the water use data used in this model did not follow a trend. This would indicate that some users reduced their water usage while others users increased their water usage. The received stories about landscape rebate programs at both AWU and SAWS support this interpretation of the quantitative results. In these stories, users who increase their water use after participation negate the net water savings from users who reduce their water use. Since survey respondents interested in water efficient landscape improvements suggested that they preferred rebates, one can assume that these participants' goals are at least partly satisfied. If this interpretation of the quantitative model is accurate, and some users are satisfied with the program, and the institution is unsatisfied with the program, then, since the program likely did not produce any water savings the hypothesis remains valid.

A Revised Actor-Network Model:

Throughout the process of conducting this study, I received many insights regarding how water conservation programs work and what affects their success. Instead of a system of just institutional-producers and citizen-consumers, the actor-network appears to be a continuously changing system that is *maintained* in part through technological momentum and *adapted* in response to new social decisions. Table 11, page 174, outlines a history of the actor-network's continuous adaption by showing key actors' and artifacts' decisions and influences, how the actors framed technology, as well as the intended and unintended consequences of these decisions on the City of Austin, the environment, and society.

Table 11: Historical Adaptation of Austin's Water Actor Network.

	Actors, Artifacts	Decision	Framing of Infrastructure	Change to Network
1890's Creating a Reservoir.	Citizens, Coalitions, Council, Water Company, Dam, Colorado River	Create public utility, control the river, grow the city.	Controlling device for large environmental risks, creation of a 'real city' with sanitary amenities.	Austin slowly gains control over its public water and Electric utilities.
Late 19th to early 20th century	Customers, Utility, streets, Pipes	Provide customers limited access to water, those on the wrong side of the street must pay more.	Equitable access to services is determined by spatial and financial considerations.	Exclusion of and higher cost to connect for some customers.
Late 1920's: Integrating services, Segregating Citizens	Residents, Planners, Consultants, Courts	City planners develop laws and plans to deliberately segregate.	Services are re-coded as mandatory objects that can promote segregation. Residents relationship to infrastructure can justify penalties.	Racial segregation of city entrenched.
Creating the LCRA and Highland Lakes	Private developers, Federal Government, Texas Legislature, Key Political Figures, Colorado River, System of Dams, City Council.	Create a system of reservoirs and dams that provide water, energy, and flood protection. Create an overseeing agency to maintain system and deliver services to Lower river basin users.	Infrastructure affected by and targeted at regional problems requires regional development and supervision.	Flood prevention, water supply security, and energy provided.
1970's-1980's: Extending Services Regionally	Voting Citizens, Water users, Bonds, Coalitions, TWDB, TWC, SDWPA, NEPA, riparian ecology, water service infrastructure.	Citizens deny bonds to constrain growth, taxes/rates. TWC enforces new environmental laws.	A political tool to maintain quality of life and cost of living. A potential source of services and pollution that can be difficult to manage.	Riparian Ecology and water quality affected. Water Conservation Division created, related programs, and policy enacted.
1984-2009: Water Treatment Plant 4	Voters in 1984, Coalitions, City Council, Engineers, Planners, Advocacy, Air Quality Legislation.	Approve bonds for a new Water Treatment Plant. Plant Planning, Site Selection, and some site development approved. Proposals for new Conservation efforts discussed.	Plant and pipes provide different benefits based on site. Site & plant can modify Air Quality, energy consumption, potential for development, ecology.	Unknown. How will an new plant affect conservation efforts?

Today’s actor-network has in part formed from the culmination of events and decisions listed in Table 11. Findings from interviews show that it is also constructed through processes of translation – a way of defining, providing incentives, and interpreting actors and artifacts within the system to create conservation programs. Program managers use conservation metrics to translate *programs* into *perceived savings*. As outlined in Chapter 6, these savings are used to provide an estimate of adjusted water demand that will help inform the overall utility water budget. Then, water budgeting is able to inform the perceived future cost of water. The creation of the future price of water includes the translation of many other predicted future conditions into plans for present water maintenance and development.

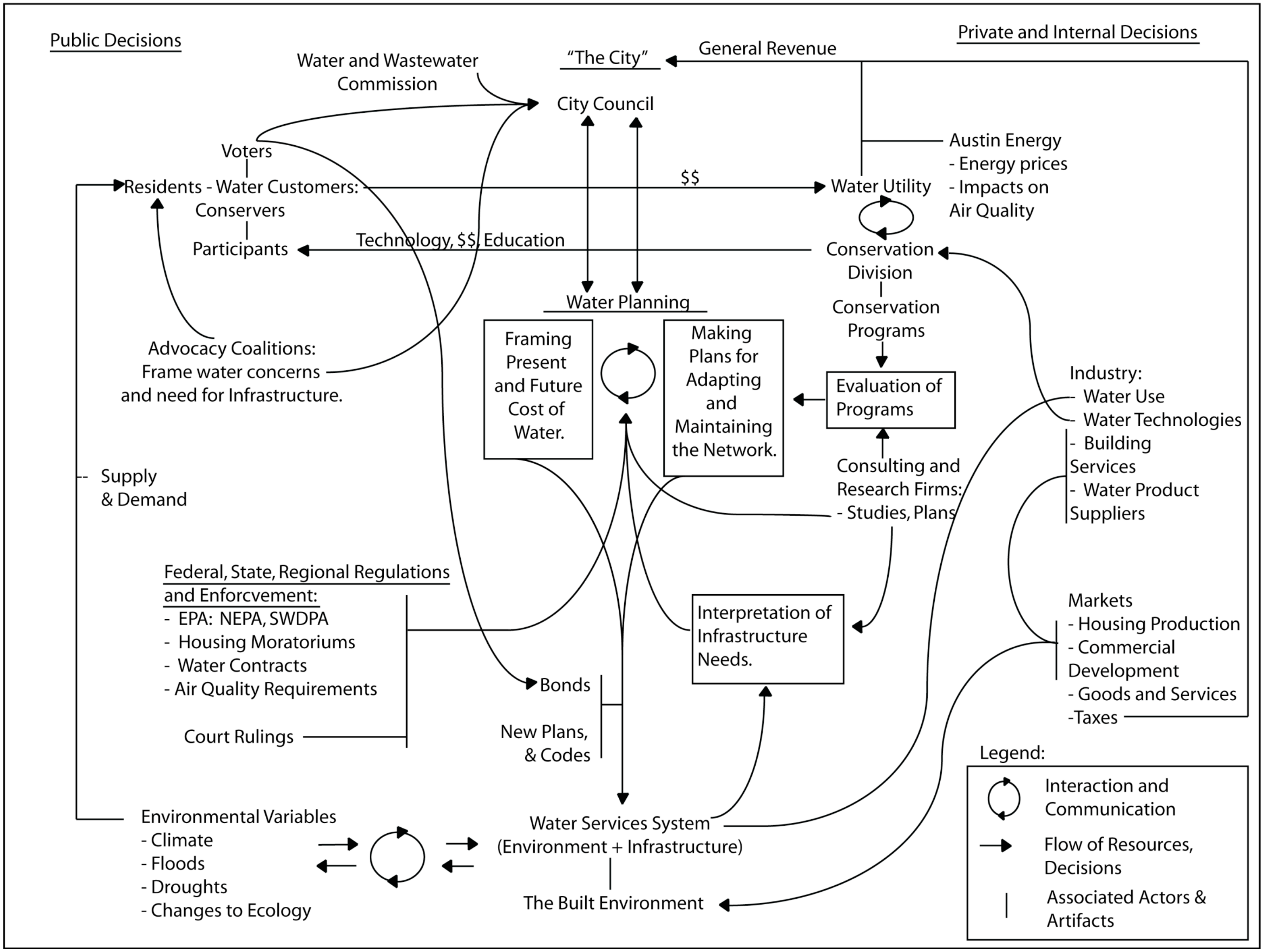
Findings also show that Austin Water Utility defines the role of the citizen-consumer through the problematization, perception of assumed savings, and the framing of a solution. Findings from both the interview and Internet study show that Austin Water Utility's framing of the citizen-consumers' role is underdeveloped and under-informed. Translating institutional needs and customers needs into conservation programs helps determine program success because it influences the willingness of customers to participate, the equitable distribution of conservation resources, and what incentives and opportunities are available for customers and the utility alike.

The received stories from respondents about how programs work, conservation metrics, conservation as commodity, and the situated value of conservation, help explain the design and implementation of conservation programs. These insights into how water conservation programs are designed and how their departments are run show how the institution maintains and adapts its network. Translating water programs into water savings and future costs into plans to maintain or adapt the network are crucial processes that determine how conservation is valued and pursued. These processes are represented within the revised actor-network model. Figure 11 illustrates a revised model of Austin's water infrastructure and water conservation actor-network that integrates these findings.

The received stories about Austin Water's programs and San Antonio Water System's programs show what Howard Davis might refer to as different 'water conservation cultures.'[149] According to Davis, these cultures will remain healthy when they successfully maintain relationships with members within their immediate community and members outside of their community. In the recommendations I will suggest ways that the water conservation culture at AWU, water conservation, and citizen-consumers could benefit from some of this study's findings.

[149] Davis, *The Culture of Building*, (1999).

Figure 11: A Revised Actor Network Model.



Recommendations:

Four recommendations can be made from this study: first, there is considerable evidence that Austin Water could redesign the network of actors involved in conserving water to enable more actors to receive benefits through water conservation. Models of engagement such as those in San Antonio provide for more opportunities to reach out and engage users. Relationships between environmental groups and the City could be cooperative and mutually beneficial instead of confrontational. Extending the actor-network to include more community groups may provide new ways of enrolling water customers as participants in the water conservation network.

Second, the utility should consider allowing previous participants who received low-performing toilets a way to receive new rebates or toilets to replace the poorly designed models subsidized by the City. This action would help provide accountability to the institutions conservation programs. By not showing such accountability the Utility undermines its reputation as a knowledgeable facilitator of water conservation that is interested in its customers satisfaction.

Third, Austin Water should re-design the actor-network created by their conservation programs to include more ways to gain knowledge of their customers' changing habits and attitudes. Instead of being a distributor of water conservation knowledge for users, the utility must also develop new user and participant knowledge for themselves. This knowledge-making process could be a cooperative effort between citizen-consumers, local environmental organizations, suppliers, builders, and the utility itself. Such knowledge may likely create what Aukum refers to as “paradigm shifts” that change the utility perception of and approach to conserving water.[150]

Fourth, the Utility should consider changing conservation incentives to reflect the multiple external benefits that can benefit the network but are often lost. This can be partly achieved by changing the City department that manages specific programs or by encouraging inter-department cooperation. Such changes and cooperative relationships already exist for the Grow Green program in Watershed Protection, and the washer rebate program’s joint rebate between Austin Water and Austin Energy.

By changing the City department that manages the program, the problem, solution, and incentive are all redefined. For instance, if the rainwater harvesting program were partially integrated with the Watershed Protection Department, the program incentive could include different types of benefits; such as impervious cover bonuses.

[150] Aukum, Jodi. Interview, (2009).

Conclusions:

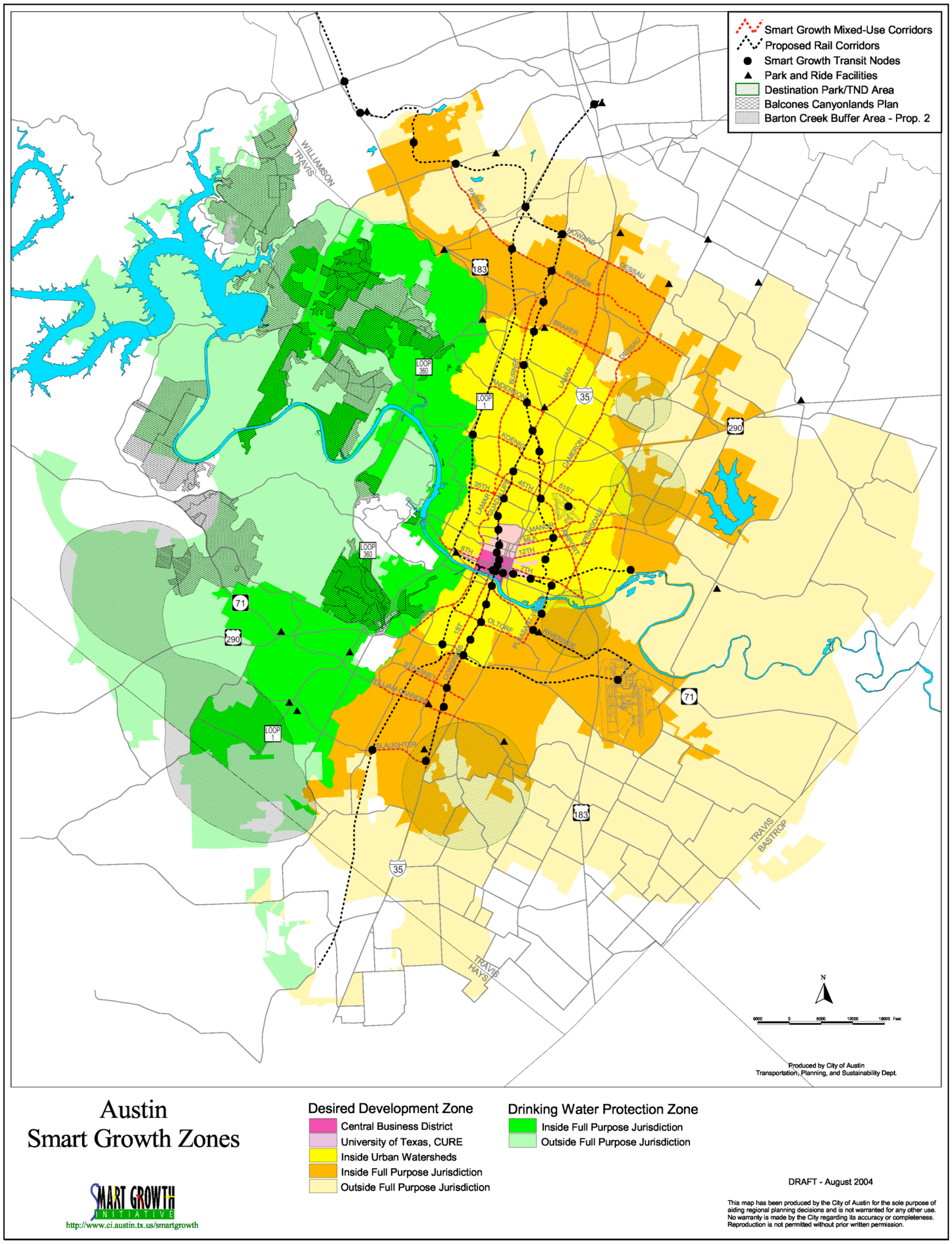
As I reflect back on the research process and production of this thesis I find that my perception of how water conservation programs achieve success has changed significantly. When I first submitted my project proposal I framed water conservation as a rather static part of demand management developed through the combined efforts of enlightened water managers and progressive citizens. Using Actor-Network Theory to analyze the empirical evidence created through these four mixed methods I believe it is clear that water conservation programs co-evolve with changing environmental, technological, and social influences. While previously I framed water conservation success to hinge upon two key actors, institutional-producers and citizen-consumers, I now believe that programs achieve success as actors within a large network adapt their relationships to pursue commonly defined goals.

I believe the use of the four methods and the actor-network analysis were appropriate and fruitful given my initial goal to create a better understanding of how water conservation programs become successful. Of course, the quality and scope of the results could always be improved. In particular, the internet survey questions could have been crafted to create a better understanding of whether survey respondents were representational of Austin Water's users as a whole. Furthermore a larger pool of survey respondents might increase the perceived reliability of the results. However, it seems to me, these sorts of problems could be addressed by refining the tactics and don't necessarily denigrate the appropriateness of the methods to answer the question posed. Actually, I found the greater challenge produced by the methods was not about insufficient or poor data, but rather it was the difficulty of deciding when useful data needed to be omitted if it did not fit the scope and specific intent of the project.

By framing water conservation programs in their larger network confounding aspects of Austin Water's infrastructure plans and conservation programs, such as the Utility's Interest in developing WTP 4, and the existence of rain barrel and landscape rebate programs, became much more clear. Water infrastructure and conservation programs are not just efforts to reduce gallons of water consumed, but are attempts to satisfy complex environmental, social, and technological relationships.

Appendix:

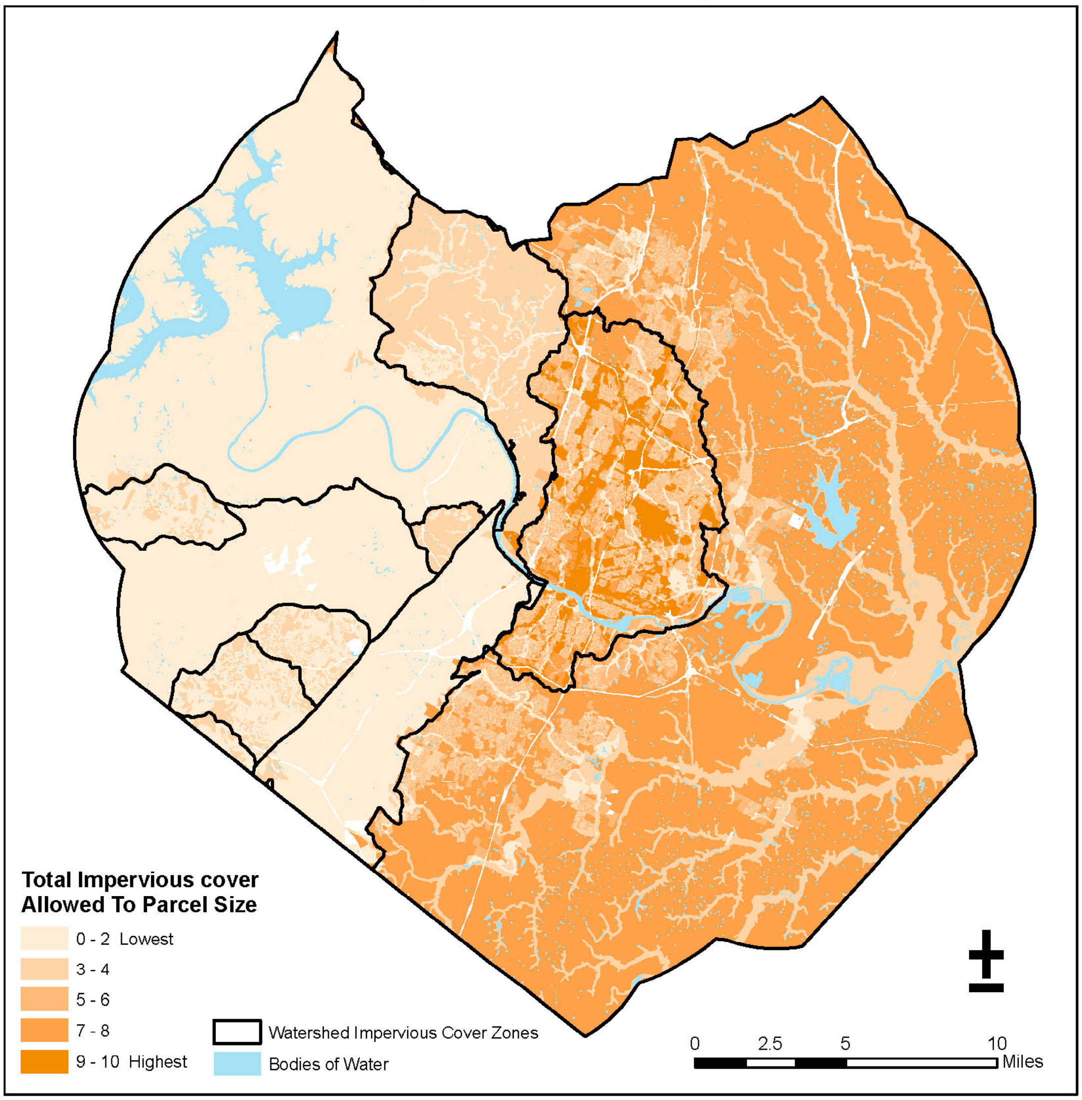
City of Austin Smart Growth Plan:



City of Austin Impervious Cover Analysis:

Urban Conservation Development Analysis for the City of Austin

Impervious Cover Analysis



Map Description:

Sources:
SOA GIS Server: Slope Data, Building footprints.
City of Austin (COA) FTP Site: Watershed, Recharge Zone, Creeks, Lakes, Transportation Impervious Cover.
CAPCOG: 100 Yr. Floodplain, Travis County Boundary, Austin City Limits.

Author: Luke Sires Published: December 13th, 2007 Projection: NAD_1983_StatePlane_Texas_Central_FIPS_4203_Feet

Interview Protocol:

1. Can you describe your role in water conservation and water provision?
2. Why do you think institutions want to conserve water?
3. Why do you think water users want to conserve water?
4. Do you believe these programs miss opportunities to conserve water?
5. Who do you think participates most in water conservation programs? Why?
6. What do you think makes water conservation programs effective or ineffective?
7. How do water infrastructure inadequacies, such as insufficient treatment plant capacity, effect water conservation programs and policy?
8. What is the relationship between water use habits and water conservation?
9. Are there any related issues that you believe should be discussed?

Internet Survey Introduction Website:

Internet Content for waterconservationstudy.net, English:

University of Texas at Austin

Master's of Science in Sustainable Design

Research Thesis:

Studies in Residential Water Conservation Programs

The purpose of this study is to examine why people conserve water and the effectiveness of water conservation programs. Your participation in the survey will contribute to a better understanding ofthis topic. We estimate that it will take about 5-10 minutes of your time to complete the questionnaire.

Take the Water Conservation Survey

Learn more about the research project and this survey

Español

Internet Content for Survey Introduction on Web and Email, English:

You are invited to participate in a survey, entitled "Studies in Residential Water Conservation Programs." The study is being conducted by Luke Sires, a Master of Science in Sustainable Design Student at The University of Texas at Austin.

The purpose of this study is to examine why people conserve water and the effectiveness of water conservation programs. Your participation in the survey will contribute to a better understanding ofthis topic. We estimate that it will take about 5-25 minutes of your time to complete the questionnaire.

Risks to participants are considered minimal. There will be no costs for participating, nor will you benefit from participating. Identification numbers associated with email addresses will be kept during the data collection phase for tracking purposes only. A limited number of research team members will have access to the data during data collection. This information will be stripped from the final dataset.

Your participation in this survey is voluntary. You may decline to answer any question and you have the right to withdraw from participation at any time without penalty. If you wish to withdraw from the study or have any questions, contact the investigator listed above. You are free to contact the investigator at the email address below to discuss the survey.

To complete the survey, click on the link below:
www.waterconservationstudy.net or, to take it in spanish:
www.waterconservationstudy.net/espanol.html

If you would like to contact the author of the study, please send an email to:
info@waterconservationstudy.net

This study has been reviewed and approved by The University of Texas at Austin Institutional Review Board. If you have questions about your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact - anonymously, if you wish - the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

IRB Approval Number: 2007-10-0074

If you agree to participate please follow the link above.

Thank you.

Internet Content for waterconservationstudy.net, English:

La University de Texas en Austin

Maestría en Ciencias de Diseño Sustenible

Tesis Investigacíon:

"Estudios en los Programas de Preservacion del Agua Residencial"

El propósito de este estudio es examinar porque la gente conserva el agua y la eficencia de los programas de preservacion del agua. Su participacion en este estudio contrubuirá a un mejor entendiemento de este asunto. Tomará aproximadamente 5-10 minutos completar el cuestionario.

Tomar el Estudio

Leer la Introduccion del Estudio

Ingles

Internet Content for Survey Introduction on Web and Email, English:

Les invito participar en una enrevista llamada "Estudios en los Programas de Preservacion del Agua Residencial." El estudio es dirigido por Luke Sires, estudiante de maestría en Ciencias de Diseño Sustenible en la Universidad de Texas en Austin.

El propósito de este estudio es examinar porque la gente conserva el agua y la eficencia de los programas de preservacion del agua. Su participacion en este estudio contrubuirá a un mejor entendiemento de este asunto. Tomará aproximadamente 5-10 minutos completar el cuestionario. Tómense la libertad ponerse en contacto con el investigador mencionado abajo para cualquier comentario o pregunta sobre este estudio.

Los riesgos a los participantes son reducidos al mínimo. No habrán costos ni recibirán beneficios por participar. Los números de identificación que refieren a las direcciones de email se guardarán durante el tiempo de coleccionar los datos solamento por facilitar ubicarlas en caso de que sea necesario. Un número limitado de los miembros del equipo tendrán acceso a los datos durante el periodo de coleccion de datos.

Esta información se eliminará del base de datos final. Su participación en este estudio es voluntario. Pueden rehusar contestar cualquiera pregunta y tendrán el derecho dejar de participar en cualquier momento sin ningúna consecuencia. Si quieren retirar del estudio o si tienen unas preguntas, favor de ponerse en contacto con el investigador nombrado arriba. Para completar la encuesta, hagan un click en el lazo de abajo:

www.waterconservationstudy.net/espanol.html o, para hacerlo in Ingles:
www.waterconservationstudy.net

Si quieren ponerse en contacto con el autor del estudio, favor de enviar un email a:

info@waterconservationstudy.net

Este estudio ha sido revisado y aprobado por The University of Texas at Austin Institutional Review Board. En cualquier momento, si tienen preguntas acerca de sus derechos como un participante en este estudio o si estan insatisfechos con cualquier aspeto del estudio, favor de ponerse en contacto (anónimo, si desean) con el Instutional Review board por telefono (512) 471-8871 o enviar un email a: orsc@uts.cc.utexas.edu.

Si están de acuerdo en participar, favor de seguir el lazo de arriba.

Muchas gracias.

Internet Survey Free Response:

	Q7. If you participated in any of the previous programs, please mention why you participated. Please select all that apply.
1	Common sense.
2	I installed all of these but didnt apply for the city rebates because a contractor is required. I di the work myself.
3	City of Austin is behind the game on utilizing grey water. I had to establish a grey water system for my lawn behind permits. In an envrioment such as now, the city is crazy to not mandate grey water as a source for landscaping.
	In addition to recieving low flow for free, the rebates were great incentives for choosing efficient system.
4	I garden, so rainbarrels make sense. The water is better for plants.
5	I currently rent and don't pay a water bill. I still have a couple of barrels from when I was a home owner but they are not set up because the current place does not have gutters.
6	Developer of my complex participated in the program.
7	our utility didn't have any programs when we moved from town to the house we built using only rainwater. We have no indor toilet, but have a 3000 gal cistern and 4 55 gal rainbarrels, a water efficient washing machine, xeric landscaping, a 'navy' shower nozzel, and are very water conscious.
8	All of the above
9	We recently installed a 2015 gal rainwater collection system and am in the process of getting a rebate for our efforts.
	Due to our recent rains the tank is filled and overflowing!
10	We surely participated in this to be a better steward because the toilets are not as functional as the old water wasters!
11	I just moved from a condo to a house and want to start participating.
12	I rennt an apartment so I do not have control of many of these options.
13	City of Austin required a more efficient toilet. (BTW, "improvements" is misspelled.)
14	I do not have a water utility. We are 100% dependent on rainwater collection.
15	The toilets don't seem to work well. I restrict watering to only the essentials. I try to save rain in a variety of containers but pour it on my plants within 2 days because of mosquitoes fear. Ever tried calling the city for info? They will only repeat the language in the brochures and can never answer any questions not all ready covered - so if you have other concerns you will not get your questions answered -- unless you call the city manager's office and complain. Then they will have a senior official in that dept. contact you & they usually have the answers. But most people are not as persistent as I am.

	Q9. What would be the best type of conservation program for your needs?
1	In-house grey water processing for garden use.
2	Rebates and watering schedules
3	I have very limited income and am a renter so if someone wanted to give me native plants, or veggies, seeds etc that's really all I can think of.
4	More info on programs that are available, and easier accessibility.
5	incentives for whole house rainwater use, also legalization of grey water use.
6	raise price of water (sliding scale)so persons who use a lot pay a lot
7	I am in an apartment that uses water allocation for the water billing. The apartment complex should get incentives to be more water efficient.
8	how to collect and entirely satisfy your water needs from rain water

9	This is a confusing question. I am not sure what it means.
10	Awareness of true cost of water usage.
11	I rent and so do a lot of other people in Austin. Maybe provide a way to let landlords know we want more water efficient appliances, etc.
12	Large quantity offers of toilets, clothes washers, dish washers, showerheads, faucet aerators, etc. that can be used to entice apartment & condo owners to switch out whole systems complex-wide...
13	allowable gray water systems, step water rates and irrigation of vegi garden with submeter
14	We live in a multi-tenant building in which the units are not individually metered. (Our condo owners' association pays the bill.) I would be able to monitor our water use better if we were metered separately.

	Q11. What do you think is the largest barrier that limits your participation in water conservation programs?
1	Awareness of these programs.
2	Time & effort required to install more efficient vegetation and landscape irrigation.
3	unemployment makes replacing working home appliances impossible. when plumbing went out, i replaced with much more efficient appliances.
4	Didn't know that it existed.
5	i'm not aware of water conservation programs.
6	I have been interested in getting a rain barrel or other water collection system, but don't have the expertise to set it up myself.
7	dont know what is out there
8	I don't need a new washer yet, so I am not purchsing one yet. They are expensive. And I don't like irrigations systems.
9	I'm not a home owner. Lots of renters want to participate in water conservation, too.
10	I have participated when it is something that is relevant to my needs.
11	timing. only makes sense to change out technologies at their end of life.
12	Apartment living hinders efficiency upgrades.
13	Competition for time. For instance, I've meant to install a rainwater collection system, but just haven't gotten around to it.
14	I do participate but cannot do some things because city won't allow.
15	
16	They are not offered in our water utility.
17	I am fully participating in water conservation and will consider futher investments in the future.
18	I am not a homeowner so don't purchase things like toilets or washing machines.
19	Difficulty of installing systems ourselves when it is too costly to have systems instaled
20	Apartments make the decisions.
21	I don't live where incentives are provided
22	No control over improvements in my apartment complex
23	I live in an apartment and my water bill is included in my rent. I don't have a lawn, and use the washer/dryer and pool of the complex, so I have minimal control over my water.
24	I live in an apartment, so I can't replace my appliances. I also don't have a yard, so outdoor water use isn't an issue.

25	I participate in water conservation. I just have not done any of the programs because all the water savings fixtures were installed in my houose already.
26	Need to generate more awareness about the programs- get the word out.
27	I rent my apartment.
28	time and money
29	None offered.
30	only system I have left to install are whole system rainwater and greywater system... the city needs to work out a greywater system policy and/or publicize it... and there need to be more maintenance companies for RH and GW systems to proivde preventative and necessary maintenance before I'll install either system.
31	I rent, so I wouldn't add any water conservation items into the rental. So I can only save by using a more efficient washing machine and limiting my other personal uses.
32	I can often do things myself for less money than hiring approved installers. My current toilet is 1.6 gpf, and rather than consuming more resources by replacing it with an even more efficient model, I use water conserving practices. This strategy also applies somewhat to my semi-efficient appliances.The embodied energy in my existing appliances is a consideration.
33	I am not the owner of my household, I am still a child in high school living under my parent's rule.
34	water bill is included in my apartment rent, so I never see how much water I use each month
35	Rent
36	As mentioned above, we are unable to monitor our water use.
37	I live in a condo. I don't have any feedback in terms of a bill, and most of the other water conservations measures don't apply to me (i.e., no lawn, no clothes washer).
	Q12. What do you think is the largest barrier that limits other central Texas residents from participating in water conservation program?
1	Awareness.
2	not sure, but if i'm not aware of the programs, i'm assuming others are not either
3	I think some other towns/cities do not have the equivalent in conservation programs and also people are not aware of the existing programs.
4	ignorance, apathy, and ignorance
5	I don't think they know much about it.
6	Many do not understand the connection between showering, flushing, washing clothes, and watering the lawn; and the cost of water on the bill. In Austin, many think it is their electric bill.
7	Lack of knowledge of programs
8	They don't have the funds to provide the matching fund needs.
9	They don't see the value in the program, for them or the environment
10	They don't have the information they need.
11	They are not offered in their water utility.
12	Proper rainwater system management of the user to realize the benefits in a manner that will save money.

13	They don't know about them, and the financial savings are not large enough to make the effort.
14	Education about the issue of water conservation is the key component - lots of folks just don't know.
15	the cost of water is too cheap
16	TV-addicted Americans are used to just turning on the tap without thinking. There are TWO KEYS:
	1/ EDUCUCATION: Give FREE WATER BILLS to households that come in with, say, a 3,000 gallon usage per month;
	have citizens in my City who use 100,000++ in a month during this State 3 Drought! For each 1,000 or 5,000 gal. of usage, tack on an extra $5.00 on the bill; for each 10,000 extra tack on $50 to $100... this has the effect of educating folks real quick about the Drought --
17	They are also renting. Or they don't care or don't believe the financial benefits outweigh the hassle.
18	They are not aware of the programs that exist
19	All of these are my # 1 barrier (in no particular order): 1) they don't know WC program's exist, 2) they don't see the impact they can make as an individual, 3) apartment and condo dwellers that don't pay for their own water use (no incentive to use less), 4) "the Joneses", 5) Home Owner's Associations landscaping requirements
20	large portion of water is in landscape and since water is still cheap and cost of landscapes overhaul is expensive initial investment, no action is taken
21	Many people do not understand the issue, so cost is often the only factor they consider. And the cost of water is not that significant for most people.
22	Rent
23	You will never get water conservation from the Republican suburbs. Won't happen until the "greens" get off their ass, put down their $200 tennis shoes and get involved in real world politics. Door to door, house to house, phone calls, meetings, etc. Don't hold your breath waiting for that to happen. There needs to be a GREATER EMPHASIS on this issue in the BLACK AND HISPANIC community where people are used to saving and conserving as a SURVIVAL technique. Last month there was a meeting - called an ENVIRONMENTAL SUMMIT - at the council chambers. Packed every seat and standing room only. There were two Hispanics and one Black in attendance. The Blacks are extremely suspicious of the enviros because the environs never seem to adopt the issues of jobs, education, crime, schools etc. that are the minority community issues. Can you name a single Black person that is in the Sierra Club or S.O.S.?? Speaks for itself. Also......enviro programs are identified with the DEMOCRATS and the Republican suburbs don't like that one bit.
24	I think there is a lack of awareness of what programs are out there and WHY water conservation is important... That is, lack of awareness/education is the greatest barrier to participation.

Internet Survey Question and Response Comparison:

A note about the tables:

The percents in these tables only show percent values for the rows, not the columns. Percents for both rows and columns are not shown, but percents for the columns can be deduced from the number of responses.

Question (Rows)	Q9. What would be the best type of conservation program for your needs?		
Question (Columns)	Q5. Do you water a lawn or other outdoor landscaping?		
	No.	Yes.	Yes, with an automatic irrigation system.
Education about basic habits and conservation	8 33%	13 54%	**3** 13%
Rebates for efficient appliances and fixtures.	19 40%	**25** 53%	**3** 6%
Incentives or requirements to water less outdoors	5 33%	7 47%	**3** 20%
Other:	7 50%	7 50%	0 0%

Question (Rows)	Q10. Which of the following conservation measures would you support? Select all that apply.		
Question (Columns)	Q5. Do you water a lawn or other outdoor landscaping?		
	No.	Yes.	Yes, with an automatic irrigation system.
Incentives for water users to stay within a voluntary monthly water budget.	37 42%	43 49%	**8** **9%**
Water conservation efforts to increase the use of alternative systems such as reclaimed water or rainwater systems for new development.	36 40%	47 52%	**7** **8%**
Reduced rate loans for water conservation oriented home and landscape improvements.	26 38%	39 57%	4 6%
Assistance for low income users.	27 39%	39 56%	4 6%
None of the above.	0 0%	1 100%	0 0%

Question (Rows)	Q6. Have you participated in any of the following types of programs through your water utility? Select all that apply:					
Question (Columns)	Q2. Which option best describes why you would participate in a water conservation program:					
	Conservation programs allow me to be a better steward of environmental resources.	Conservation programs allow my water utility to provide better and more affordable services.	Conservation programs help me reduce my bills.	Conservation programs let me save on improvements I would make anyway.	I would not participate in a water conservation program.	Row Totals
Received a discounted or free efficient toilet.	22 67%	2 6%	6 18%	3 9%	0 0%	25%
Received a discounted or free rainbarrel.	11 61%	2 11%	5 28%	0 0%	0 0%	14%
Received a discounted water efficient washing	17 74%	0 0%	3 13%	3 13%	0 0%	17%
Received a discount to install a larger (300 gallons	1 100%	0 0%	0 0%	0 0%	0 0%	1%
Participated in an irrigation audit.	0 0%	0 0%	**1** 100%	0 0%	0 0%	1%
Received support to install vegetation with low water	**7** 70%	1 10%	1 10%	1 10%	0 0%	8%
I havent done any of these.	38 83%	1 2%	6 13%	1 2%	0 0%	35%

Question (Rows)	Q6. Have you participated in any of the following types of programs through your water utility? Select all that apply:				
Question (Columns)	Q7. If you participated in any of the previous programs, please mention why you participated. Select all that apply:				
	I didnt participate in any of the previously mentioned programs.	This/these programs allow me to be a better steward of environmental resources.	This/these programs allow my water utility to provide better and more affordable services.	This/these programs let me save on improvemets I would make anyway.	Other:
Received a discounted or free efficient toilet.	0 0%	**24** **44%**	7 13%	**15** **28%**	8 15%
Received a discounted or free rainbarrel.	0 0%	14 44%	5 16%	7 22%	6 19%
Received a discounted water efficient washing	0 0%	**14** **40%**	5 14%	**15** **43%**	1 3%
Received a discount to install a larger (300 gallons +) rainwater harvesting system.	0 0%	**1** 50%	0 0%	0 0%	1 50%
Participated in an irrigation audit.	0 0%	**1** **33%**	**1** **33%**	**1** **33%**	0 0%
Received support to install vegetation with low water needs.	0 0%	**8** **47%**	2 12%	3 18%	4 24%
I havent done any of these.	34 89%	0 0%	0 0%	0 0%	4 11%

Question (Rows)	Q6. Have you participated in any of the following types of programs through your water utility? Select all that apply:				
Question (Columns)	Q9. What would be the best type of conservation program for your needs?				
	Education about basic habits and conservation technology.	Rebates for efficient appliances and fixtures.	Incentives or requirements to water less outdoors (such as a mandatory watering schedule).	Other:	Row Totals
Received a discounted or free efficient toilet.	5 15%	17 52%	6 18%	5 15%	33 25%
Received a discounted or free rainbarrel.	1 6%	11 61%	3 17%	3 17%	18 14%
Received a discounted water efficient washing machine.	5 22%	11 48%	6 26%	1 4%	23 18%
Received a discount to install a larger (300 gallons +) rainwater harvesting system.	0 0%	1 100%	0 0%	0 0%	1 1%
Participated in an irrigation audit.	0 0%	0 0%	1 100%	0 0%	1 1%
Received support to install vegetation with low water needs.	0 0%	6 60%	3 30%	1 10%	10 8%
I havent done any of these.	13 29%	22 49%	4 9%	6 13%	45 34%
Column Total	24	68	23	16	131

Question (Rows)	Q8. Have you done any of the following ***without*** assistance from you water utility? Select all that apply:				
Question (Columns)	Q9. What would be the best type of conservation program for your needs?				
	Education about basic habits and conservation technology.	Rebates for efficient appliances and fixtures.	Incentives or requirements to water less outdoors (such as a mandatory watering schedule).	Other:	Row Totals
Replaced an inefficient toilet with an efficient	8 35%	10 43%	2 9%	3 13%	23 13%
Installed a rainbarrel.	1 6%	7 41%	5 29%	4 24%	17 9%
Purchased an efficient washing machine.	5 19%	13 50%	4 15%	4 15%	26 14%
Installed a larger (300 gallons +) rainwater	1 10%	5 50%	2 20%	2 20%	10 5%
Monitor irrigation system regularly.	6 30%	8 40%	4 20%	2 10%	20 11%
Planted vegetation with low water needs.	16 24%	31 46%	12 18%	9 13%	68 37%
I havent done any of these.	5 28%	8 44%	2 11%	3 17%	18 10%
Column Total Column Percent	42 23%	82 45%	31 17%	27 15%	182 100%

Qustion (Rows)	Q6. Have you participated in any of the following types of programs through your water utility? Select all that apply:								
Question (Columns)	Q14. It is useful to know the general level of income for people responding to this survey.								
	Under $20,000	$20,000 but less than $30,000	$30,000 but less than $40,000	$40,000 but less than $50,000	$50,000 but less than $60,000	$60,000 but less than $80,000	$80,000 but less than $100,000	$100,000 & over	I would rather not share this information.
Received a discounted or free efficient toilet.	0 0%	2 6%	3 9%	3 9%	3 9%	3 9%	12 36%	5 15%	2 6%
Received a discounted or free rainbarrel.	1 6%	0 0%	3 17%	0 0%	1 6%	1 6%	8 44%	0 0%	4 22%
Received a discounted water efficient washing machine.	**1** **4%**	**1** **4%**	**2** **9%**	**3** **13%**	2 9%	0 0%	6 26%	4 17%	4 17%
Received a discount to install a larger (300 gallons +) rainwater harvesting system.	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1 100%	0 0%	0 0%
Participated in an irrigation audit.	0 0%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0%	1 100.00%	0 0.00%	0 0.00%
Received support to install vegetation with low water needs.	**1** **10%**	**0** **0%**	**1** **10%**	**1** **10%**	**0** **0%**	**1** **10%**	**4** **40%**	**2** **20%**	**0** **0%**
I havent done any of these.	2 4%	6 13%	5 11%	10 22%	4 9%	8 17%	3 7%	5 11%	3 7%
Column Total Column Percent	5 4%	9 7%	14 11%	17 13%	10 8%	13 10%	35 27%	16 12%	13 10%

Question (Rows)	Q8. Have you done any of the following ***without*** assistance from you water utility? Select all that apply:								
Question (Columns)	Q14. It is useful to know the general level of income for people responding to this survey.								
	Under $20,000	$20,000 but less than $30,000	$30,000 but less than $40,000	$40,000 but less than $50,000	$50,000 but less than $60,000	$60,000 but less than $80,000	$80,000 but less than $100,000	$100,000 & over	I would rather not share this information.
Replaced an inefficient toilet with an efficient toilet.	0 0%	0 0%	1 4%	4 17%	4 17%	3 13%	4 17%	5 22%	2 9%
Installed a rainbarrel.	1 6%	0 0%	3 18%	2 12%	2 12%	2 12%	4 24%	2 12%	1 6%
Purchased an efficient washing machine.	1 4%	0 0%	1 4%	5 19%	3 12%	3 12%	5 19%	5 19%	3 12%
Installed a larger (300 gallons +) rainwater harvesting system.	1 10%	0 0%	2 20%	1 10%	1 10%	0 0%	4 40%	1 10%	0 0%
Monitor irrigation system regularly.	1 5%	1 5%	1 5%	4 20%	2 10%	0 0%	6 30%	5 25%	0 0%
Planted vegetation with low water needs.	4 6%	4 6%	11 16%	10 15%	6 9%	5 7%	13 19%	7 10%	8 12%
I havent done any of these.	1 5%	3 16%	1 5%	3 16%	1 5%	5 26%	2 11%	2 11%	1 5%
Column Total	9	8	20	29	19	18	38	27	15

Question (Rows)	Q8. Have you done any of the following ***without*** assistance from you water utility? Select all that apply:				
Question (Columns)	Q2. Which option best describes why you would participate in a water conservation program:				
	Conservation programs allow me to be a better steward of environmental resources.	Conservation programs allow my water utility to provide better and more affordable services.	Conservation programs help me reduce my bills.	Conservation programs let me save on improvements I would make anyway.	I would not participate in a water conservation program.
Replaced an inefficient toilet with an efficient	**17** **74%**	2 9%	**3** **13%**	1 4%	0 0%
Installed a rainbarrel.	**12** **71%**	1 6%	**3** **18%**	1 6%	0 0%
Purchased an efficient washing machine.	**16** **62%**	2 8%	**6** **23%**	2 8%	0 0%
Installed a larger (300 gallons +) rainwater	**8** **80%**	0 0%	**1** **10%**	1 10%	0 0%
Monitor irrigation system regularly.	**13** **65%**	1 5%	**4** **20%**	2 10%	0 0%
Planted vegetation with low water needs.	**49** **72%**	3 4%	**11** **16%**	5 7%	0 0%
I havent done any of these.	**16** **84%**	1 5%	**1** **5%**	1 5%	0 0%

Quantitative Model Expanded Results:

Results from Quantitative Model:

(Solution for Fixed Effects)

All Estimate values in hundreds of gallons.

All Users Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept	1141.87	3.3231	<.0001
Yearly Trend (for all 5 years)	-25.623	0.2535	<.0001
Change in use per person in Household	56.8982	5.3197	<.0001
Change in use per 1 ft^2 of house	0.3011	0.00515	<.0001
Change in use per 5 ft^2 of lot	0.02177	0.00078	<.0001
Change in use per month per inch of rain	-102.41	1.1276	<.0001

Free Toilet Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	1040.6200	12.9744	<.0001
Yearly Trend (for all 5 years)	-26.0436	5.9311	<.0001
Participation year effect	-49.0710	6.5751	<.0001
Effect after participation (for last 3 years	17.2284	4.1339	<.0001
Change in use per person in Household	44.3921	15.0611	0.0032
Change in use per 1 ft^2 of house	0.1448	0.0176	<.0001
Change in use per 5 ft^2 of lot	0.0080	0.0028	0.0046
Change in use per month per inch of rain	-63.9484	4.7643	<.0001

Toilet Rebate Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	1226.08	22.045	<.0001
Yearly Trend (for all 5 years)	-14.8278	9.2797	0.1101
Participation year effect	-61.1576	15.941	<.0001
Effect after participation (for last 3 years	-6.6849	10.0183	0.5046
Change in use per person in Household	32.4404	31.8211	0.308
Change in use per 1 ft^2 of house	0.2958	0.02653	<.0001
Change in use per 5 ft^2 of lot	0.01806	0.003742	<.0001
Change in use per month per inch of rain	-110.46	6.5032	<.0001

Washer Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	1358.58	24.7039	<.0001
Yearly Trend (for all 5 years)	-11.2523	11.5496	0.33
Participation year effect	-59.0653	19.1725	0.0021
Effect after participation (for last 3 years	-29.2746	12.8108	0.0223
Change in use per person in Household	79.1319	31.9702	0.0133
Change in use per 1 ft^2 of house	0.3255	0.02648	<.0001
Change in use per 5 ft^2 of lot	0.02983	0.00382	<.0001
Change in use per month per inch of rain	-100.01	7.2127	<.0001

Results from Quantitative Model: (Continued)
(Solution for Fixed Effects)
All Estimate values in hundreds of gallons.

Irrigation Audit Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	2280.72	85.7948	<.0001
Yearly Trend (for all 5 years)	13.6553	44.6768	0.76
Participation year effect	-163.77	75.1066	0.0295
Effect after participation (for last 3 years	-167.22	48.8884	0.0007
Change in use per person in Household	168.82	107.63	0.1171
Change in use per 1 ft^2 of house	0.2905	0.08132	0.0004
Change in use per 5 ft^2 of lot	0.04381	0.01081	<.0001
Change in use per month per inch of rain	-187.72	29.9384	<.0001

Rain Barrel Sales Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	1109.21	28.1461	<.0001
Yearly Trend (for all 5 years)	-57.7138	7.714	<.0001
Participation year effect	0.5048	12.3473	0.9674
Effect after participation (for last 3 years	6.1361	7.451	0.4103
Change in use per person in Household	89.009	50.1868	0.0763
Change in use per 1 ft^2 of house	0.292	0.04018	<.0001
Change in use per 5 ft^2 of lot	0.01436	0.006604	0.0298
Change in use per month per inch of rain	-115.83	10.8405	<.0001

Landscape Rebate Results:

Description	Estimate	Standard Error	Pr > |t|
Intercept Value	923.13	187.03	<.0001
Yearly Trend (for all 5 years)	-79.2217	95.7792	0.4105
Participation year effect	135.74	156.93	0.3895
Effect after participation (for last 3 years	105.99	103.99	0.311
Change in use per person in Household	31.6778	238.57	0.8947
Change in use per 1 ft^2 of house	0.3466	0.2409	0.154
Change in use per 5 ft^2 of lot	0.02605	0.04071	0.5239
Change in use per month per inch of rain	7.4452	58.847	0.8996

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